OPERATION AND MAINTENANCE

OUTSIDE PLANT

project

mercury

prepared for NASA

MS-121

project
mercury

OUTSIDE PLANT

prepared for
National Aeronautics and Space Administration
Contract No. NAS 1-430

February, 1961

WESTERN ELECTRIC COMPANY, INC.

TABLE OF CONTENTS

PART I

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

PART I

LIST OF TABLES

TABLE OF CONTENTS

PART II

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

PART II

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

PART II

TABLE OF CONTENTS

PART III

LIST OF ILLUSTRATIONS

PART III

LIST OF TABLES

PART III

TABLE OF CONTENTS

PART IV

LIST OF ILLUSTRATIONS

PART IV

PART I

SECTION 1. DESCRIPTION

1.1 GENERAL INFORMATION

This manual describes the outside plant, installed at Mercury sites, as provided in the Project Mercury Ground Communication Plan. The outside plant consists of cables, transmission lines, antennas, and associated supports, hardware, tools, and test equipment.
This manual includes component descriptions, installation, test, and maintenance information for the above items and is subdivided as follows:

a. Part I—Cable and Associated Equipment

b. Part II—Transmission Lines

c. Part III—Antennas—Land Sites

d. Part IV—Antennas—Ship Sites

1.1.1 Scope of Part I

Part I of this manual includes information and data relative to outside plant (cable), as follows:

a. Physical and functional descriptions of the cable plant used at Mercury sites.

b. Installation and splicing information for buried and aerial cable.

c. Block diagrams of the cable facilities at each site.

d. Maintenance schedules and procedures, where applicable to cable plant.

e. List of tools and test equipment and information on their use in cable maintenance.

f. Parts list of outside plant (cable) items and an index of site drawings applicable to cable plant.

1.1.2 System Functions

The cables described in this manual provide the facilities which are required to interconnect the various buildings and equipment vans at the Mercury sites.

Circuits provided by these cables are used for communications and equipment operation on site as well as for termination (at some sites) of common carrier leased circuits to the Goddard Space Flight Center (GSFC) and the Mercury Control Center (MCC).

1.1.3 System Characteristics

The types of signals to be transmitted between the various buildings and vans vary in frequency from 0 to 13,000 cps, and are composed of square, complex, and sine waves.

No single facility has the characteristics to meet the transmission requirements of all these signals. Several facilities are supplied to provide the cable system. They are:

a. Communications cable

b. Synchro cable

c. Plotboard cable

1.1.3.1 *Communications Cable*

This cable is standard Western Electric Co. manufactured cable and is reliable, readily available, compatible with existing installations, and can be supplied with tape armor for buried installations.

1.1.3.2 *Synchro Cable*

This is a special cable, manufactured to meet the requirements of low shunt capacity and a high degree of capacity balance.

1.1.3.3 *Plotboard Cable*

This is a special cable, manufactured to meet the requirements of low loss, high signal-to-noise ratio, and low shunt capacity. This cable is also referred to as a radar display cable.

1.2 PHYSICAL DESCRIPTION

1.2.1 Communications Cable

1.2.1.1 *General*

Since August 1952, exchange type cables have been coded in accordance with a 4-letter system which indicates:

a. First Letter—Sequence of standardization

b. Second Letter—Dielectric strength of insulation

c. Third Letter—Gauge and material of conductors

d. Fourth Letter—Type of sheath

For about 30 years prior to that date, a three-letter code was employed which did not include a letter to designate the type of sheath. The following table indicates the significance of the letters used in the code designations:

TABLE I

CODE DESIGNATIONS USED FOR EXCHANGE TYPE CABLE

First Letter	*Second Letter*	*Third Letter*			*Fourth Letter*
		Gauge and Material of Conductor			
Sequence of Standardization	*Dielectric Strength*	*GA*	*Copper*	*Aluminum*	*Type of Sheath*
Alphabetical progression from A	S = 350 Volts rms	13	J		A = Alpeth
		16	H		C = Stalpeth
	N = 500 Volts rms	17		C	D = Lepeth
		19	B		E = Polyethylene Jacket
	K = 5,000 Volts dc				F = Polyethylene Jacket Lepeth
	H = 10,000 Volts dc	20		D	
		22	A	F	
		24	M	K	L = Lead
		26	T		G = Polyethylene-Aluminum-Polyethylene (PAP)
		28	W		H = Polyethylene Aluminum Steel and Polyethylene (PASP)

TABLE I—CODE DESIGNATIONS USED FOR EXCHANGE TYPE CABLE (Continued)

(Example)

Polyethylene Insulated Conductor Cables

The symbol for this cable is the 4-letter code, number of pairs, and descriptive symbol.

BHBA-50 17, 1-50	50-pair polyethylene insulated conductor cable. The cable number and pair count are indicated on the second line. The significance of BHBA may be determined from the data in the table above.

1.2.1.2 *Communications Cable Description*

The communications cables are solid conductor, polyethylene-insulated (PIC) cables manufactured by the Western Electric Co. They have the even-count PIC color code and are of unit construction.

The sizes, from 6 through 25 pairs, consist of a single unit.

The basic subdivision in other sizes is the binder group, which has 25 distinctively colored pairs. A binder group may consist of a single 25-pair unit or a combination of 8-8-9 or 12- and 13-pair units having the same colored binding strings. The pairs in each binder group and the binder strings are color coded in such a way as to permit selection of any binder group and any pair in the cable by color. (See Figure 1-1). Paragraph 2.3.2.5 shows the individual pair color code for cables of 6 through 25 pairs, and for the units comprising the 25-pair binder groups used in the remaining sizes.

The cables have polyethylene, aluminum, and polyethylene (PAP) sheaths and for buried application, the PAP cable is further protected by buried-tape armor (BT).

The code designations and other descriptive information covering types of cables used at Mercury sites are tabulated below.

a. Type BHAA Multiple Sheath Cables

(1) *Conductors*—No. 22 gauge copper.

(2) *Insulation*—Solid polyethylene.

(3) *Sheath*—Aluminum and polyethylene.

(4) *Conductor Resistance*—Approximately 171 ohms per-loop-mile of cable. Maximum not to exceed 186 ohms per-loop-mile of cable at 68° F.

(5) *Dielectric Strength* — Insulation between conductors capable of withstanding a dc potential of not less than 8000 volts. Insulation between conductors and sheath capable of withstanding a dc potential of not less than 10,000 volts.

(6) Capacitance: Average mutual ac capacitance 0.083 uf per mile of cable. Maximum average not to exceed 0.090 uf per mile of cable at 60° F.

(7) Attenuation: Approximately 1.8 decibels at 1000 cps.

(8) Primary Use: Outside plant, general.

(9) All cables are fully color coded:

Code	*Minimum Good Pairs*	*Approximate Over-All Diameter (Inches)*	*Approximate Weight per Foot (Lbs)*
BHAA11	11	0.50	0.12
BHAA16	16	0.55	0.15
BHAA25	25	0.64	0.20
BHAA50	50	0.81	0.35

Code	Minimum Good Pairs	Approximate Over-All Diameter (Inches)	Approximate Weight per Foot (Lbs)
BHAA75	75	1.01	0.52
BHAA100	100	1.12	0.66
BHAA150	150	1.33	0.93
BHAA200	200	1.49	1.20
BHAA300	300	1.83	1.76
BHAA400	400	2.08	2.30
BHAA600	600	2.47	3.37

b. Type BHBA Multiple Sheath Cables

(1) Conductors: No. 19 gauge copper.

(2) Insulation: Solid polyethylene.

(3) Sheath: Aluminum and polyethylene.

(4) Conductor Resistance: Approximately 85 ohms per-loop-mile of cable. Maximum not to exceed 92 ohms per-loop-mile of cable at 68° F.

(5) Dielectric Strength: Insulation between conductors, and between conductors and sheath, capable of withstanding a dc potential of not less than 10,000 volts.

(6) Capacitance: Average mutual ac capacitance 0.083 uf per mile of cable. Maximum average not to exceed 0.090 uf per mile of cable at 60° F.

(7) Attenuation: Approximately 1.3 decibels at 1000 cps.

(8) Primary Use: Outside plant, general.

CORE MAKE-UP OF EVEN PIC CABLES

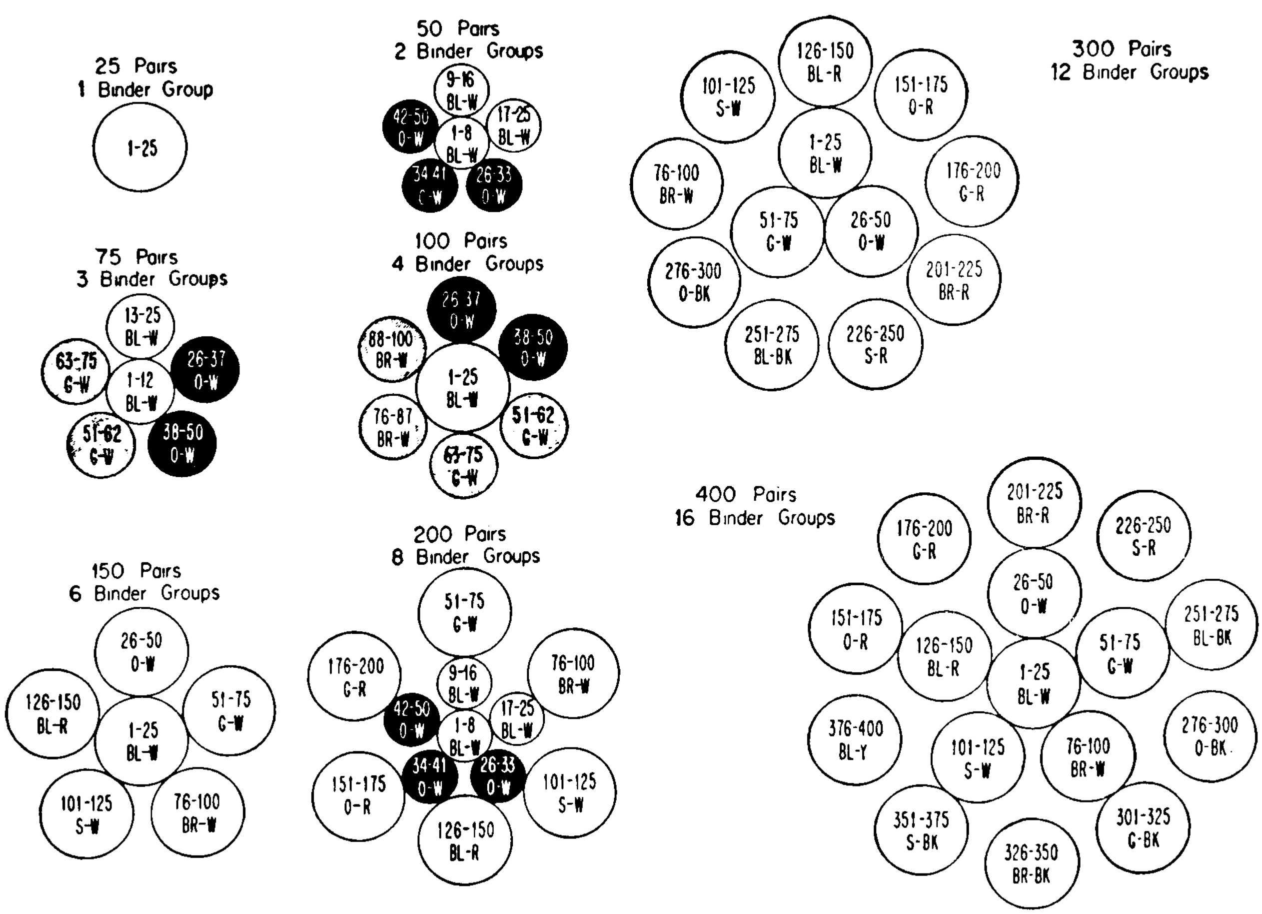


FIGURE 1-1. CORE MAKEUP OF EVEN PIC CABLES

(9) All cables are fully color coded:

Code	Minimum Number of Good Pairs	Approximate Over-All Diameter (Inches)	Approximate Weight per Foot (Lbs)
BHBA6	6	0.51	0.13
BHBA11	11	0.61	0.19
BHBA16	16	0.69	0.25
BHBA25	25	0.81	0.35
BHBA50	50	1.13	0.65
BHBA75	75	1.33	0.92
BHBA100	100	1.49	1.19
BHBA150	150	1.83	1.74
BHBA200	200	2.08	2.27
BHBA300	300	2.47	3.32

c. Type BHBG Multiple Sheath Cables

(1) Conductors: No. 19 gauge copper.

(2) Insulation: Solid polyethylene.

(3) Sheath: Polyethylene, aluminum, and polyethylene.

(4) Conductor Resistance: Approximately 85 ohms per-loop-mile of cable. Maximum not to exceed 92 ohms per-loop-mile of cable at 68° F.

(5) Dielectric Strength: Insulation between conductors capable of withstanding a dc potential of not less than 10,000 volts. Insulation between conductors and sheath capable of withstanding a dc potential of not less than 20,000 volts.

(6) Capacitance: Average mutual ac capacitance 0.084 uf per mile of cable. Maximum average not to exceed 0.090 uf per mile of cable at 60° F.

(7) Attenuation: Approximately 1.3 decibels at 1000 cps.

(8) Primary Use: Outside plant, buried.

(9) All cables are fully color coded:

Code	Minimum Number of Good Pairs	Approximate Over-All Diameter (Inches)	Approximate Weight per Foot (Lbs)
BHBG6	6	0.61	0.16
BHBG11	11	0.71	0.23
BHBG16	16	0.79	0.29
BHBG25	25	0.98	0.43
BHBG50	50	1.23	0.72
BHBG75	75	1.44	1.01
BHBG100	100	1.67	1.31
BHBG150	150	1.96	1.88
BHBG200	200	2.22	2.45
BHBG300	300	2.62	3.56

(a) A piece of noncoded CA-1914G-LA cable was suplied at Bermuda only. It is Western Electric Co. cable with characteristics as BHBG and is a PAP cable with a light wire armor.

d. Type BHBG-BT Multiple Sheath Cables

(1) BHBG-BT consists of type BHBG cable protected against mechanical injury and low-frequency induction by asphalt compound, impregnated paper, metal tape, and impregnated jute. Average mutual ac capacitance 0.085 uf per mile of cable. Maximum average not to exceed 0.092 uf per mile of cable at 60° F.

(2) Primary Use: Outside plant, buried.

Code	Approximate Over-All Diameter (Inches)	Approximate Weight per Foot (Lbs)
BHBG6BT	0.93	0.76
BHBG11BT	1.03	0.91
BHBG16BT	1.11	1.02
BHBG25BT	1.30	1.30
BHBG50BT	1.64	2.08
BHBG75BT	1.85	2.58
BHBG100BT	2.10	3.12
BHBG150BT	2.39	3.98
BHBG200BT	2.65	4.79
BHBG300BT	3.07	6.33

1.2.2 Synchro Cable

The synchro cables are of special design and are manufactured by the General Cable Co. Two cable types are required:

Type 1 — Consists of three (No. 16 gauge) twisted triads, shielded and jacketed plus one (No. 12 gauge) twisted pair, shielded and jacketed.

Type 2—Consists of five (No. 16 gauge) twisted triads, shielded and jacketed and two (No. 12 gauge) twisted pairs, shielded and jacketed.

Cross-section views of the two cable types are shown in Figure 1-2.

The color coding is in accordance with MIL-W-16878, type B/N.

Shielding and jacketing is in accordance with MIL-W-16878C type B/N, except jacket shall be polyethylene. Other descriptive items covering the two types of synchro cable are:

a. DC resistance : 1.92 ohms/k[1] (No. 12 AWG)
4.85 ohms/k[1] (No. 16 AWG)

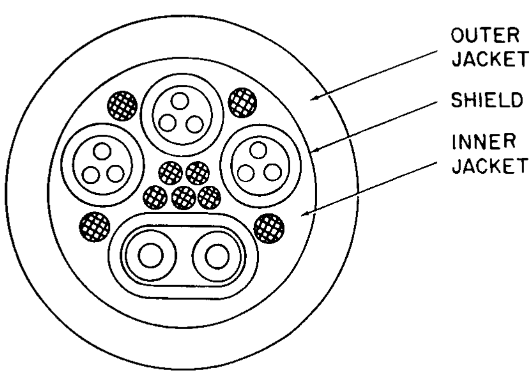
b. Inner jacket : 0.600-inch polyethylene

c. Shield : 0.005-inch tin-plated copper tape wrap

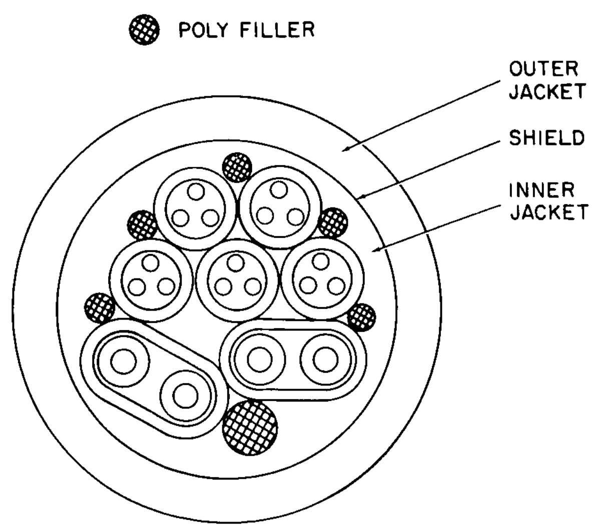
d. Outer jacket : 0.070-inch polyethylene

e. Cable OD : Type 1—1.10 inches
Type 2—1.35 inches

f. Max. capacity : 35 mmf/ft.



TYPE I SYNCHRO CABLE
ONE NO.12 TPSJ
THREE NO.16 TTSJ
TIN/COPPER TAPE OVER-ALL SHIELD



TYPE 2 SYNCHRO CABLE
TWO NO.12TPSJ
FIVE NO.16 TTSJ
TIN/COPPER TAPE OVER-ALL SHIELD

FIGURE 1-2. SYNCHRO CABLE

1.2.3 Plotboard Cable

The plotboard cable is of special design and is manufactured by the General Cable Co. The cable consists of six (No. 14 AWG) uncoated, annealed-copper conductors, which are insulated with color-coded polyethylene and individually shielded. Other descriptive items covering this cable are:

a. Conductor insulation : 0.085-inch polyethylene

b. Conductor shield : No. 34 AWG tinned-copper shield

c. Cable shield : 0.005-copper tape

d. Outer jacket : 5/64-inch polyethylene

e. Cable OD : 1.02 ±0.01 inch

A cross-section view of the plotboard cable is shown in Figure 1-3.

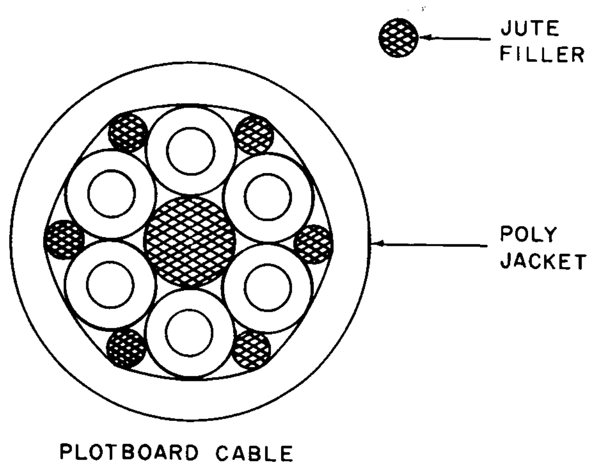


FIGURE 1-3. PLOTBOARD CABLE

1.3 FUNCTIONAL DESCRIPTION

1.3.1 Communications Cable

The communications cable will be used to transmit the following signals:

Type	*Frequency*	*Remarks*
Voice	300 to 3000 cps square	
Teletype	waves up to 600 PPS 300 to 3000 LPS Tone	DC Loops VF Carrier
Telemetry	1000 to 12000 cps	Freq. Response ± 1 db 6-microsecond delay
Control voltages	DC signals	Relay operation
Timing pulses	Square waves up to 1000 pps	100-microsecond max. rise time

1.3.2 Synchro Cable

The synchro cable is used to transmit synchro data to servo mechanisms on the pedestals of directional antennas, which track and maintain communications with the capsule. This data is in the form of azimuth and elevation information and three conductors are required for each path. The signal is in the form of ac phase shift between the three conductors. An ac reference pair to each pedestal is also required.

1.3.3 Plotboard Cable

The plotboard cable is used to transmit X, Y, and Z information, from the Verlort radar to the plotboard located at the acquisition aid console, in the form of varying dc potentials. Six conductors are required for each path. This cable is shown in cross section in Figure 1-3.

1.4 EQUIPMENT SUPPLIED (OTHER THAN CABLES)

1.4.1 Index

Indexed below are the major outside plant items used in connection with the installation of the cables described in paragraph 1.2.1.

Paragraph 1.4.2 describes and lists the uses of the equipment items indexed in this section.

Equipment Items	*Remarks*	*Paragraph*
Terminal Sections—1A1, 2A1	Major Items	1.4.2.1
Terminal Block—1A4A	Major Items	1.4.2.2
Wire Terminal—104B	Bermuda Installation Only	1.4.2.3
Multiple-Drop Wire—C	Bermuda Installation Only	1.4.2.4
Splice Cases—9A, 10A, 11A, 12A	Bermuda Installation Only	1.4.2.5
Conduit—Transit	Bermuda & Canton Only	1.4.2.6
Manhole Items	Bermuda & Canton Only	1.4.2.7
Lashing Wire—Copper, Steel	Hardware Items	1.4.3.1
Wrap Lock—Stainless Steel	Hardware Items	1.4.3.2
Cable Clamps—Nos 10, 21	Hardware Items	1.4.3.3
Drop Wire Clamp—D	Hardware Items	1.4.3.4
Rubber Conduit Plug	Hardware Items	1.4.3.5
Splice Cover	Splicing Items	1.4.4.1
Splice Case Adapters—133A, B	Splicing Items	1.4.4.2
Sealing Washers	Splicing Items	1.4.4.3
Sleeves—Filled, Copper, Plastic	Splicing Items	1.4.4.4
Sealing Cord	Splicing Items	1.4.4.5
Sealing Tape	Splicing Items	1.4.4.5
Duct Seal-Plastic	Splicing Items	1.4.4.6
Desiccant—B-160 grams	Splicing Items	1.4.4.7
Shielding Braid	Splicing Items	1.4.4.8
Misc Items	Splicing Items	1.4.4.9

1.4.2 Major Items—Description and Use

1.4.2.1 *Terminal Sections—1A1, 2A1*

The 1A1 and 2A1 cable terminal sections are constructed of sheet metal and accommodate single or multiple installations of 1A3A or 1A4A terminal blocks. The 1A1 section is an intermediate section, which, when combined with the 2A1-type end section, forms the housing of a wall-type terminal. The intermediate section consists of two parts: a back with a top and bottom and a snap-on cover. Three knockouts are provided in the top and bottom for the entrance of cable and wire. Wiring rings are located in the corners of the 1A1 section. Two 2A1 sections are used to close the sides of one or a group of 1A1 sections.

The over-all dimensions of the terminal sections are shown in Figure 1-4.

1.4.2.2 *Terminal Blocks—1A4A*

The 1A4A terminal blocks are fuseless, protected building terminal blocks which consist of a gas-proof, cast-selectron block, mounting brackets, and fanning strip. (See Figure 1-4.) The 1A4A terminal block is equipped with a 12-foot, 24-gauge, PVC insulated conductor lead-covered stub. Viewing the 26-pair block from the front with the stub at the top, pair one is terminated at the top of the left row of binding posts, with the white conductor on the left post and the blue conductor on the right post. The number 26 pair is on the lower right. The color coding is shown in paragraph 2.3.2.5 of this manual.

The blocks are equipped with 107C protectors which have a square head shell as a means of distinguishing it. Details of the 107C protector are illustrated in Figure 1-4.

1.4.2.3 *Wire Terminal—104B*

The 104B wire terminal consists of a cast-metal housing having a hinged metal cover and contains terminals moulded in a terminal block. The block is arranged to terminate six pairs of conductors, and rubber grommets are provided in the housing for entrance of the wires. The 104B wire terminal is arranged for mounting on poles, cross arms, or walls and is intended for use in terminating the drop wire, described in paragraph 1.4.2.4, and local station wires. No protection is supplied in the 104B terminal. Its dimensions are shown in Figure 1-5.

1.4.2.4 *Multiple Drop Wire—C*

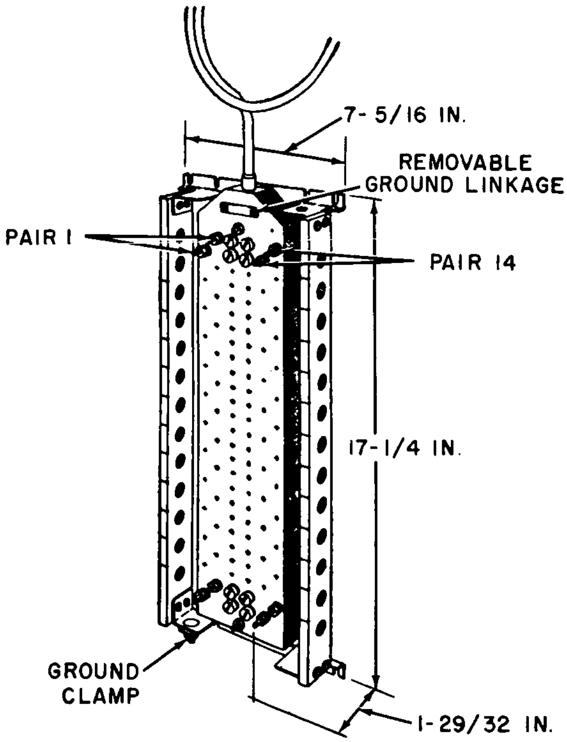
Multiple drop wire consists of six twisted-conductor pairs. Each conductor is rubber insulated and neoprene jacketed. The six pairs are cabled together and wrapped with glass-yarn tape into a tight core. The assembly is encased in a black neoprene jacket. The color code is given in paragraph 2.4.2.3 and the wire is illustrated in Figure 1-5.

Multiple drop wire is used for making multiple connections between two stations or an aerial cable terminal, and station terminals where fuseless type or no station protection is required. It is designed for aerial installation of short length.

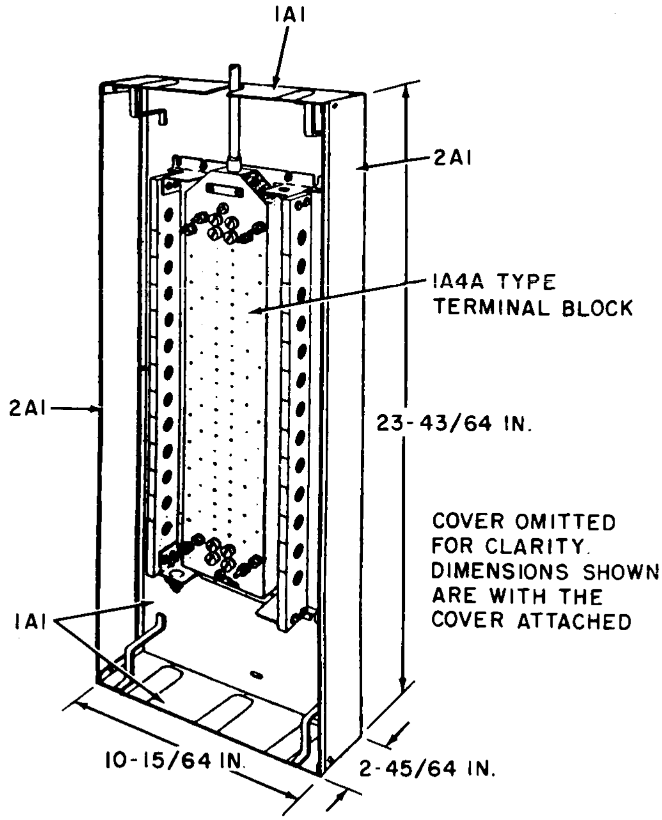
1.4.2.5 *Splice Cases—9A, 10A, 11A, 12A*

A splice case consists essentially of a cast-metal housing with a semicylindrical cavity and is provided with pipe plugs for pressure testing. Two splice cases of the same code number are required for a complete splice closure. These metal housings are shown on Figure 1-6. The size and type of each splice case and the cable diameter and kind of splice with which each is used are shown in the following listing:

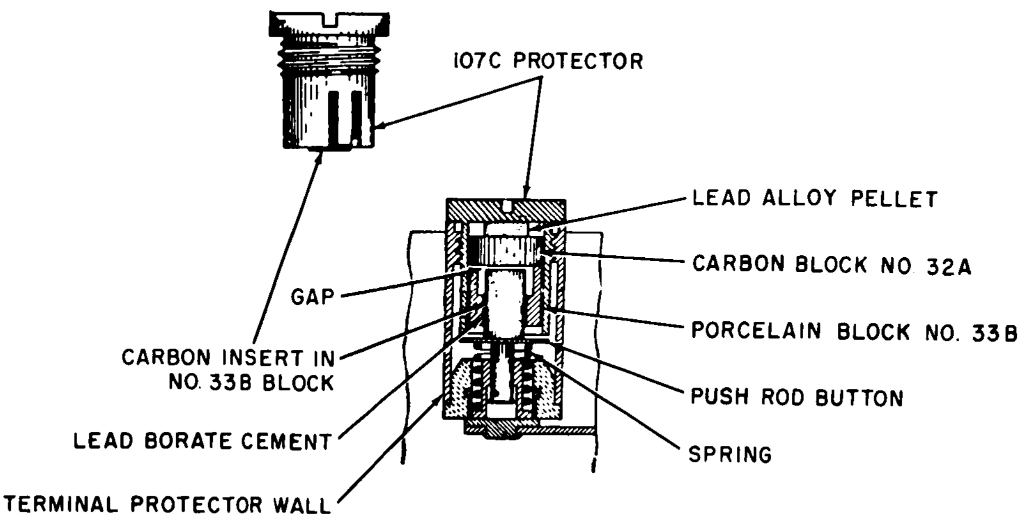
Kind of Splice	*Cable Diameter (Inches)*	*Type of Splice Case (Two Required)*
Straight	0.3 to 1.6	9A
	1.6 to 2.9	10A
Y	0.3 to 1.6	11A
	1.6 to 2.9	12A
Double Y	0.3 to 1.6	11A
	1.6 to 2.9	12A



1A3A & 1A4A-26 TERMINAL BLOCK

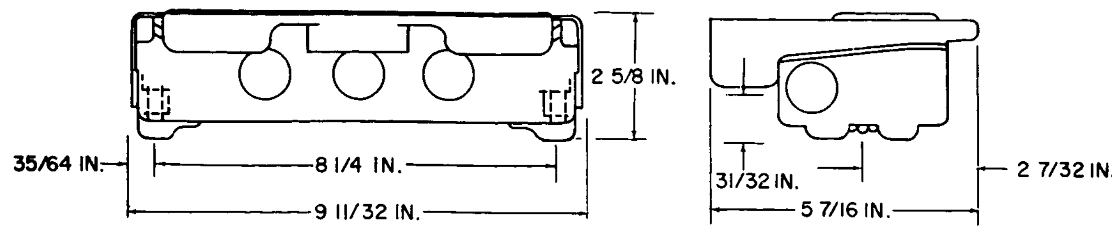


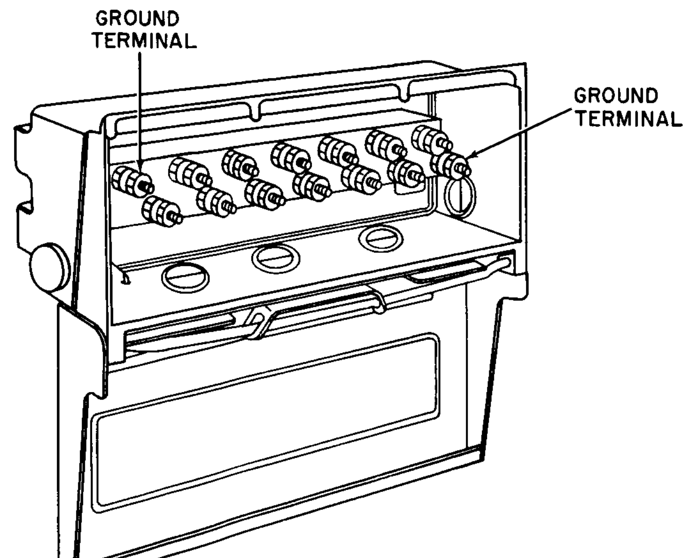
1A1 & 2A1 CABLE TERMINAL SECTIONS



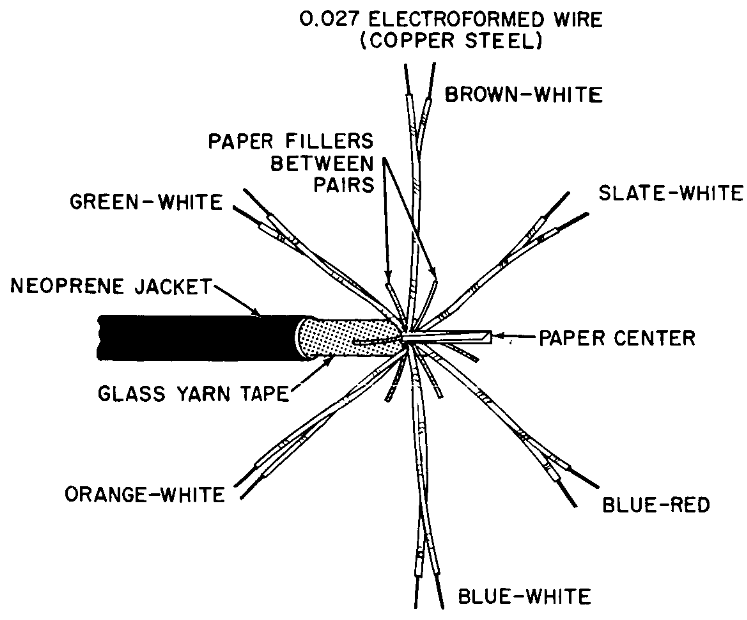
107C PROTECTOR

FIGURE 1-4. 1A3A AND 1A4A-26 TERMINAL BLOCKS, 1A1 AND 2A1 CABLE TERMINAL SECTIONS, AND 107C PROTECTOR





104B WIRE TERMINAL



C MULTIPLE DROP WIRE

FIGURE 1-5. NO. 104B WIRE TERMINAL, C MULTIPLE DROP WIRE, AND 104B WIRE TERMINAL

Each splice case is shipped in an individual carton, which is not waterproof and should not be unduly exposed to the weather. Each of the two cartons required for an individual installation also includes one half of the small hardware needed for a complete splice enclosure. The items furnished are listed below.

PART	*	USED FOR	Number (Quantity) of Parts furnished with each case — Case Number 9A	10A	11A	12A
Clamp	129A Adapter Assembly	Installing Cables smaller than 1 inch Diameter	1		2	
Spacer	133C Adapter Assembly	Installing Cables from 1.6 inch to 2.2 inch Diameter		1		2
Inner Sheath Clamp	P46A911 Clamp	Slides under sheath tabs for clamping	1		2	
	P10C093 Clamp			1		2
Cap Screw 3/8 in x 16 x 1½ in.	Screw, Hex H Cap C Res 3/8 in x 16 x 1½ in	For joining splice cases and securing compression collars	10	12	12	16
Nut	P14A861 Nut		10	12	12	16
Compression Collars	P14A860 Collar	Two piece collar which compresses sealing tape between washers to form end seal around cable		2		4
	P15A078 Collar		2		4	
1/8 in Pipe Plug	P13A314 Plug	Pressure testing fitting	1	1	1	1
Stainless Steel Washer		Placed between cap screw and compression collar	2		4	

* This information should be used when ordering parts.

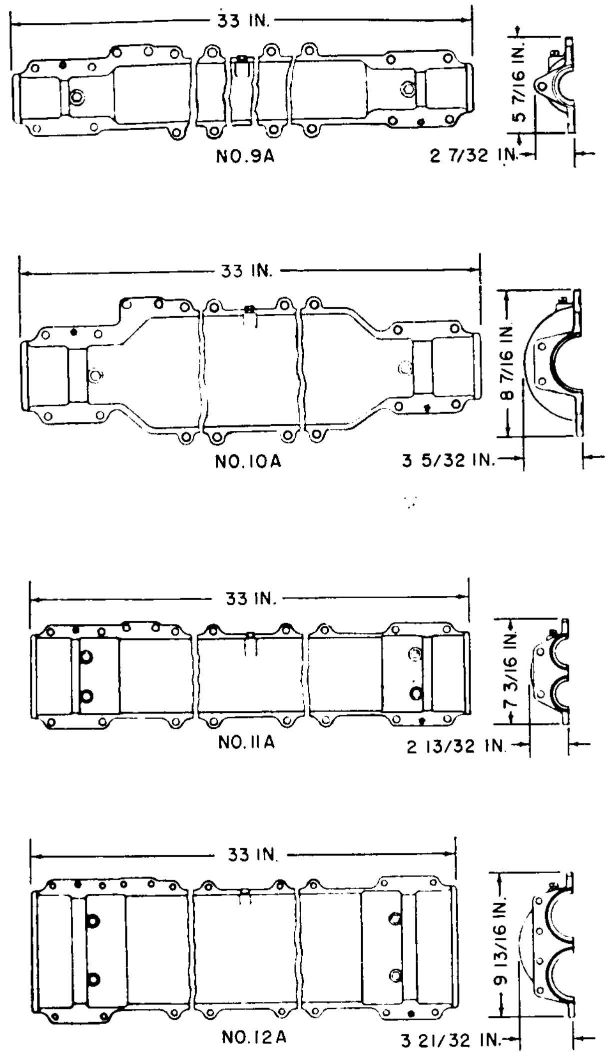


FIGURE 1-6. SPLICE CASES

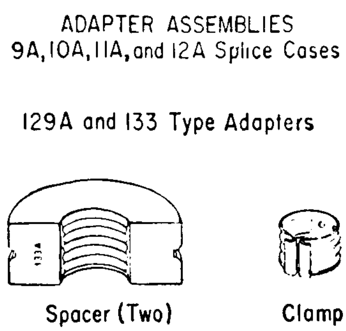
The following materials are not furnished with the splice cases and must be ordered separately.

Item	*Use*	*Quantities Required*
B-type sealing tape (package unit 3-10-in. strips)	Sealing ends of splice cases	4-6 packages
B-type sealing cord (package unit 2-32-in. lengths)	Sealing sides of splice cases	2 packages required per installation

(Continued)

Item	Use	Quantities Required
Sealing washers	Sealing ends of splice cases	4 required per cable. See paragraph 1.4.4.3 for sizes
P-18A-678 ground lug	Bonding as required	1 required per installation

The 133B and 133C adapters, which may be required in addition to the ones furnished with the splice cases to assemble small cables in the 10A and 12A splice cases, must be ordered separately. The adapter assemblies are furnished complete and the cable diameter and splice case with which each is used are shown below. (See paragraph 1.4.4.2.)



Diameter of Cable to be Installed (Inches)	Adapter used in Splice Cases 9A and 11A	10A and 12A
0-1.0	129A	133A
1.0-1.6		133B
1.6-2.2		133C

The 9A, 10A, 11A, and 12A splice cases are intended for use as part of a gas- and moisture-tight splice closure for straight and branch splices on multiple-sheath cables having an inner layer of polyethylene. In cases where only one cable hole is used at either end of a complete splice closure, the unused holes must be plugged.

Splicing is described in paragraph 2.3.2.9, and illustrated in Figure 2-6.

1.4.2.6 *Transite Conduit*

Transite conduit is an asbestos-cement composition conduit which has considerable mechanical strength. The conduit used at Bermuda is 3-1/2 inches inside diameter. One coupling is furnished with each length of conduit. (See Figure 1-7.)

Single C-type transite cement conduit may be buried directly in the soil, if sufficient cover is provided, or a concrete cover may be used, as shown in the Bermuda site drawing, T-6G02-361. A concrete encasement is not required.

The manhole and conduit system at Bermuda (Coopers Island) is designed to allow access to the main underground cable route and provide a means of carrying branch or subsidiary cables from the underground feeder cables to the telemetry and control building terminations.

1.4.2.7 *Type B Manholes*

The manholes, constructed at Bermuda, in connection with the Project Mercury installation are of concrete construction and are detailed on the site drawing T-6G02-360.

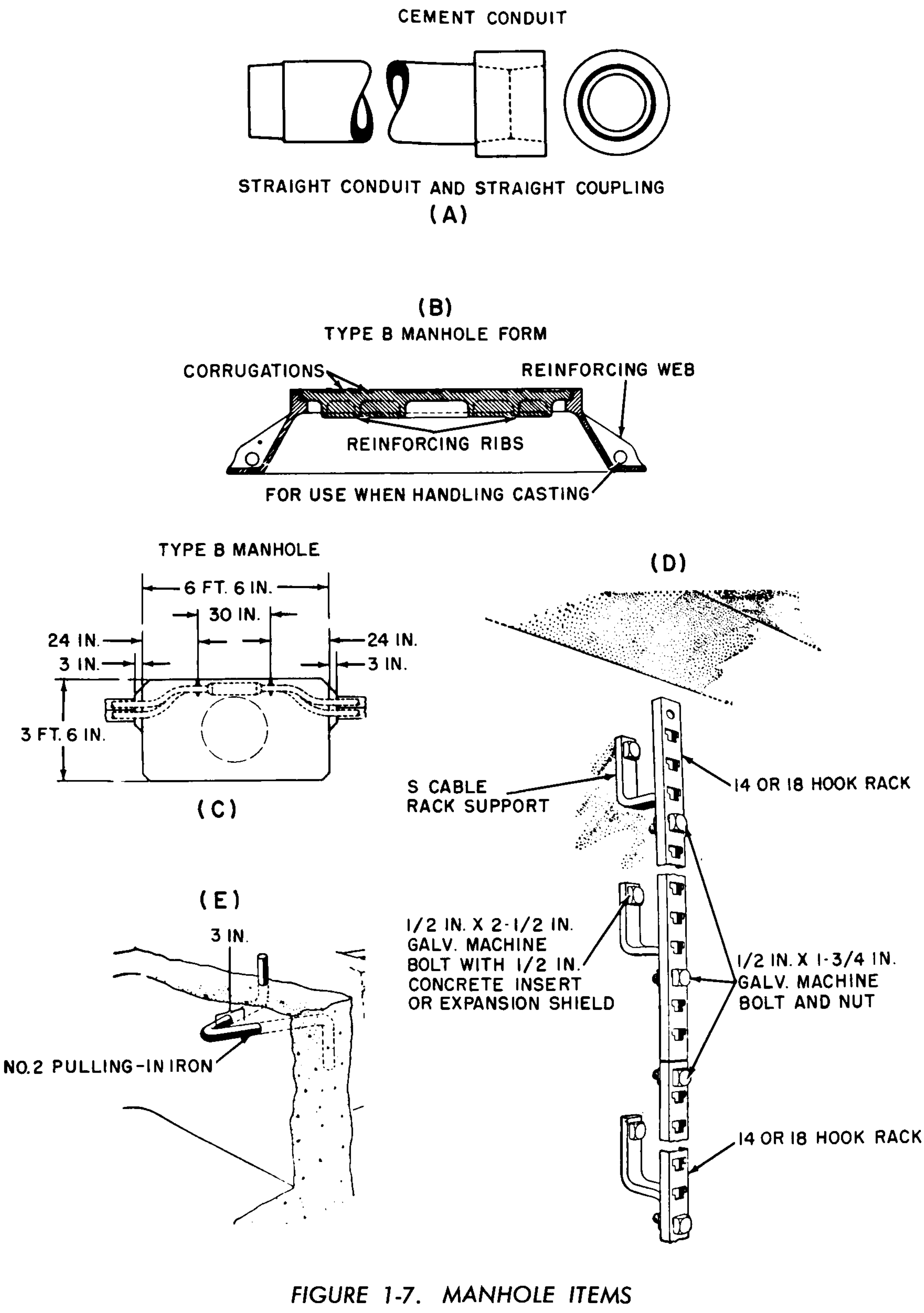


FIGURE 1-7. MANHOLE ITEMS

The primary purposes of manholes are to provide:

a. Ready accessible space in the underground conduit system for joining cable sections, taking off subsidiary cable, and splicing in stubs for flexibility.

b. Location points for items of equipment necessary to the proper maintenance and efficient operation of underground cable plant.

Type B manholes may be specified in runs of six or less ducts and thus are somewhat smaller in size, and cost less to construct. The type B has a field of use, however, where rearrangements can be kept to a minimum and the number of ducts is small.

A typical type B manhole is shown in Figure 1-7.

The items associated with manhole construction are:

(1) *Manhole Frame*—A cast-iron frame for supporting the cover of the manhole. (See Figure 1-7B.)

(2) *Concrete Insert*—An assembled unit consisting of a 1/2-inch machine bolt and a malleable iron threaded sleeve with flanges to provide anchorage in the concrete manhole wall.

(3) *Manhole Opening Form*—A form for use in making the proper opening in the poured-concrete roof of the manhole.

(4) *Manhole Recess Form*—A form for use in recessing duct entrances in the end and side walls of concrete manholes. The B- and C-type units provide a recess 3 inches deep, with a flat panel 2 inches wide and are of use primarily in end walls. The forms, which are of the six-duct size are attached to the entering conduit by means of duct plugs provided with each form.

(5) *Manhole Ladder*—A galvanized-steel ladder for use in manholes where headroom is more than 5 feet. Rungs are spaced on 12-inch centers.

(6) *Manhole Cover*—A cast-iron cover for manhole openings. It may or may not have ventilation holes.

(7) *Pulling-In Iron*—An attachment, set into manhole walls below duct entrances, to be used in connection with cable-pulling devices. (See Figure 1-7.)

(8) *Cable Hook M*—A monel metal hook, used with the M-type cable racks, for supporting cables in a manhole.

(9) *Cable Rack M*—A monel metal channel, 1-1/2 inches in width, which, when attached to rack supports and fitted with cable hooks, is used to support cables in manholes. (See Figure 1-7.)

(10) *Cable Rack Support*—A galvanized, bent steel bar for supporting cable racks in the manholes. (See Figure 1-7.)

The above manhole items are covered further in paragraph 2.2.3.

1.4.3 Hardware Items—Description and Use

1.4.3.1 *Lashing Wire Copper*

A tinned annealed-copper wire, which is used for attaching duct-splice tags to cables and for lashing stub and main cables together.

1.4.3.2 *Steel Construction Wire*

A galvanized, annealed, low-carbon wire used for serving guys. It is No. 10 BWG and comes 1/2 mile per 129 lb spool.

1.4.3.3 *Wrap Lock*

A 1/2 inch stainless-steel banding material used in anchoring or supporting cables or conduits. It is supplied 100 feet per can. The can also contains a wrench, cotter pins, keys, and buckles for completing the band.

1.4.3.4 *Cable Clamps*

Galvanized-steel clamps or straps used to fasten cables to various kinds of surfaces, buildings, and poles.

The standard cable clamps and straps and the minimum and maximum cable diameters with which each can be used are shown in the following listings. The diameters of the various types and sizes of cable are given in other sections of the practices.

CABLE CLAMPS

Cable Diameter (Inches) *Minimum*	*Maximum*	*Cable Clamp Number*
0.25	0.33	4
0.34	0.43	6
0.44	0.52	7
0.53	0.60	8
0.40	0.59	9
0.61	0.72	10
0.60	0.72	11
0.73	0.93	13
0.94	1.20	17
1.21	1.45	21
1.46	1.70	25
1.71	2.00	30
2.01	2.40	35
2.41	2.70	42

CABLE STRAPS

Cable Diameter (Inches) *Minimum*	*Maximum*	*Cable Strap Number*
0.51	0.56	9
0.57	0.69	11
0.70	0.81	13
0.82	1.00	16
1.01	1.25	20
1.26	1.50	24
1.51	1.88	30
1.89	2.25	36
2.26	2.63	42
2.64	3.50	56
3.51	4.00	64

1.4.3.5 *Drop Wire Clamp, D*

A special clamp for attaching multiple-drop wire to a building or pole. It consists of two semicircular shells and two flat wedges held together by a tail wire. The clamp is illustrated in Figure 2-1(A) of paragraph 2.2.1.

1.4.3.6 *Rubber Conduit Plug*

A soft, expansible rubber plug with galvanized steel plates and bolts used for sealing the ends of ducts against water and gas. The split plugs are for use in ducts occupied by cables and the solid plugs are for use in unoccupied ducts.

1.4.4 Splicing Items—Description and Use

1.4.4.1 *Splice Cover, C&D*

A rubber tube 5 feet long and 7 inches in diameter, which is intended for use as temporary protection of uncompleted splices. The cover is powdered to prevent sticking and is equipped with a valve for pressure testing. The C-type cover is for a straight splice and the D cover is for a Y splice.

1.4.4.2 *Splice Case Adapters—133* (Paragraph 1.4.2.5)

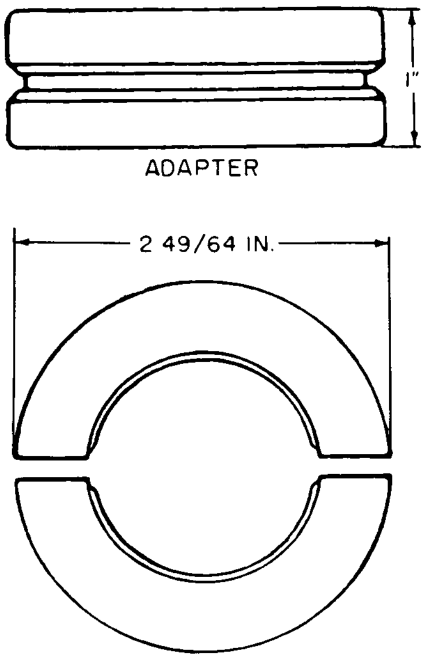
Each consists of two cast-metal spacers, a clamping ring (shipped loose), and a length of lashing wire (shipped loose).

a. *No. 133A, B, & C*—Intended for use with No. 10A and 12A, 20D and 21D splice cases.

b. *No. 133A*—Arranged for use with cables 1 inch and less in diameter.

c. *No. 133B*—Arranged for use with cables over 1 inch to 1.6 inches in diameter.

d. *No. 133C*—Arranged for use with cables over 1.6 inches to 2.2 inches in diameter.



1.4.4.3 *Sealing Washers*

Polyethylene washers for use in connection with splice cases. The B-type washer 100 series has a center hole with a radial slit and is for use with splice cases accommodating cables up to 1-1/2 inches in diameter. The B-type 200 series is similar and is for use with splice cases accommodating cables up to 2-1/2 inches in diameter. The D-type washers are for plugging the unused opening in a splice case or may be used instead of the B-type sealing washer by cutting along the proper annular groove with a B-type washer cutter. Such washers are furnished in the following sizes:

B Sealing Washers				*D Stealing Washers*	
Size	*Dia of Hole (Inches)*	*Size*	*Dia of Hole (Inches)*	*Size*	*OD in Inches*
103	0.3	210	1.0	100	1-1/2
104	0.4	211	1.1	200	2-1/2
105	0.5	212	1.2		
106	0.6	213	1.3		
107	0.7	214	1.4		
108	0.8	215	1.5		
109	0.9	216	1.6		
110	1.0				

C- and E-type sealing washers, made of lead, are used to confine the B-type sealing tape used with splice cases. The C-type sealing washers are for use in sealing unused entrances to splice cases, for cables 1.6 inches in diameter and larger, in splice cases having entrance cavities of 2-23/32 inches or 3-15/32 inches in diameter. The E-type sealing washers are used in the same-size splice cases for cables smaller than 1.6 inches in diameter, by inserting the proper size B- or D-type sealing washer in the recess provided. Such washers are available in the following sizes:

C-TYPE SEALING WASHERS

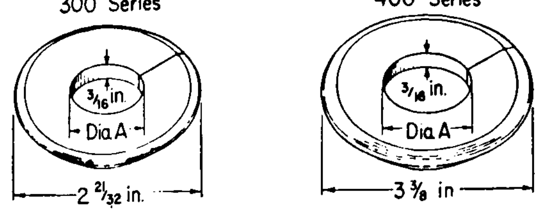
Size	*Dia A (Inches)*	*Size*	*Dia A (Inches)*
300*	0	400*	0
311	1.1	416	1.6
312	1.2	417	1.7
313	1.3	418	1.8
314	1.4	419	1.9
315	1.5	420	2.0
316	1.6	421	2.1
317	1.7	422	2.2
318	1.8	423	2.3
319	1.9	424	2.4
320	2.0	425	2.5
321	2.1	426	2.6
322	2.2	427	2.7
		428	2.8
		429	2.9

* For sealing unused openings in splice cases.

E-TYPE SEALING WASHERS

Series	*Dia A*	*Dia B*	*Series*	*Dia A*	*Dia B*
3100	1½ in.	2⅝ in.	4100	1½ in.	3⅜ in.
			4200	2⅛ in.	3⅜ in.

C Sealing Washers

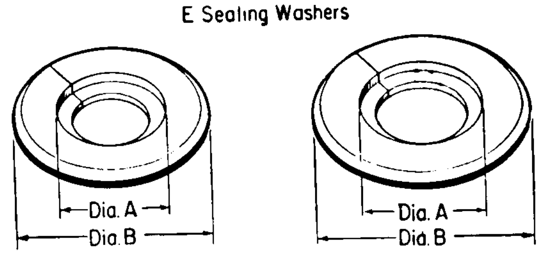


Size	Dia A
300 *	0 IN.
311	1.1 IN.
312	1.2 IN.
313	1.3 IN.
314	1.4 IN.
315	1.5 IN.
316	1.6 IN.
317	1.7 IN.
318	1.8 IN.
319	1.9 IN.
320	2.0 IN.
321	2.1 IN.
322	2.2 IN.

* For sealing unused openings in splice cases.

Size	Dia A
400 *	0 IN.
416	1.6 IN.
417	1.7 IN.
418	1.8 IN.
419	1.9 IN.
420	2.0 IN.
421	2.1 IN.
422	2.2 IN.
423	2.3 IN.
424	2.4 IN.
425	2.5 IN.
426	2.6 IN.
427	2.7 IN.
428	2.8 IN.
429	2.9 IN.

E Sealing Washers



1.4.4.4 *Copper Sleeve*

For joining 16 or larger-gauge cable conductors by soldering. Single-tube sleeves are for making straight splices. Double-tube sleeves are for making butt and bridge splices. Sleeves are slotted longitudinally to facilitate soldering. Length 1-1/2 inches. The size number indicates the gauge of conductor to be joined. S indicates single and D indicates double tube.

Code No.	*Packaging Quantities* Small per Pkg	Large per 10 Pkgs
10-D	200	2400
10-S	100	4000
13-D	100	1800
13-S	50	2000
16-S	250	4500

1.4.4.5 *Filled Sleeve*

For insulating pigtails in polyethylene-insulated conductor cable. Consists of polyethylene tubes 2-1/2 inches long, sealed at one end and filled with a silicone compound. They are furnished in the following dimensions:

1.4.4.6 *Plastic Sleeve*

A vinyl-plastic sleeve for use in insulating splices between plastic-insulated cable conductors. Sleeves are 3-1/2 inches long with a 0.020-inch wall thickness and are packed in telescopic boxes. These splices provide high-dielectric insulation at splices but are not watertight and are intended for use on aerial cable.

Size	*Inside Dia (Inch)*	*Type of Splice*	*Color*	*Weight per Package (Ounces)*	*Packaging Quantities* Small per Pkg	Large per 20 Pkgs
125	0.125	*19 x 22 or 22 x 22	White	9	325	6500
145	0.145	*19 x 19 x or 22 x 22 x 22	Red	9	260	5200
165	0.165	19 x 19 x 22 or 19 x 19 x 19	Blue	9	200	4000

* For 22-gauge conductors having expanded polyethylene insulation, use next larger-size sleeve.

Designation	*Inch*	*Color*	*Weight per Package (Ounces)*	*Packaging Quantities Small per Pkg*	*Large per 50 Pkgs*
133	0.133	Red	14	450	22500
166	0.166	Yellow	14	300	15000
208	0.208	Green	12	225	11250

1.4.4.7 *Sealing Cord B*

An easily deformed compound consisting of plasticized synthetic rubber, containing carbon black, and is used for sealing cable splice cases. It is 32 inches long and 9/32 inch in diameter.

1.4.4.8 *Sealing Tape B*

Similar to sealing cord (1.4.4.7), furnished in three 10-foot lengths per package.

1.4.4.9 *Plastic Duct Seal*

A putty-like material, which retains a degree of plasticity in service, for use in closing conduit openings.

NOTE

It should not be used in contact with cable having an outer covering of polyethylene.

1.4.4.10 *Desiccant B*

A white granular material available in screw-top cans (moisture proof) of 160 grams. It is used to absorb moisture in connection with the splicing of cables.

1.4.4.11 *Copper, Iron Shielding Braid*

Wire mesh, 36 gauge, for wrapping splices at expansion joints to make shielding continuous and to make armor of the UG distribution cables, electrically continuous.

1.4.4.12 *Miscellaneous Items*

Item	*Description and Use*
Cloth, wire, B	Wire cloth 2 inches wide. Supplied in packages containing 20 pieces, 2 inches wide x 12 inches long. About 2 pieces needed per splice. For making joints in alpeth-sheath cable.
Paint, asphalt, No. 2	Available in 1 pt, 1 qt, 1 gal, 5 gal, and 55 gal containers. For painting taped openings and splices in buried cable.
Muslin	Supplied by the yard in 36-inch widths. Also available in a 2-inch width (4 to 6 yards long), and in a 4-inch width (7 to 10 yards long). The 36-inch width is used for wrapping splices and ventilating manholes. The 2- and 4-inch widths are used for wrapping splices.
Tape, aluminum, B	Aluminum tape with adhesive on one side. Supplied in rolls 4 inches wide containing 20 linear feet. About 5 feet required per splice. For making joints in alpeth-sheath cable.

(Continued)

1.4.4.12 *Miscellaneous Items* (Cont'd)

Item	*Description and Use*
Tape, B	Neoprene tape with one tacky surface. Supplied in rolls 2 inches wide containing 15 linear feet. About one roll required per splice. When 1/2 or 1-inch strips are called for, they can be cut from the 2-inch tape. For making joints in alpeth-sheath cable.
Tape, cambric, varnished	Supplied in rolls 1-1/2 inches wide and 25 feet long. For insulating the butt at sheath openings in high-dielectric strength cables.
Tape, cotton	Available in 1/2-inch and 1-inch width, in 2-ounce and 4-ounce rolls, respectively. For protecting the core from the sheath at cable openings.
Tape, CR	Available in 1-inch, 2-inch, and 28-inch widths in 20-foot rolls. For use at temporary openings, insulating joints, and for covering splices in buildings.
Tape, electrical, scotch	Available in 3/8-inch and 1/2-inch widths in rolls of 10 yards and 36 yards. For general splicing work.
Tape, electrical, scotch No. 27	Glass cloth tape. Supplied in rolls 3/4 inch wide x 30 feet long. For terminating tape armor and for insulating joints.
Tape, friction	Available in a 3/4-inch width for 1/4- and 1/2-lb rolls, and in a 2-inch width for 1/2- and 1-lb rolls. For general splicing work.
Tape, polyethylene, B	Supplied in rolls 3 inches wide x 100 feet long. For wrapping splices in high-dielectric strength cable.
Tape, rubber	Available in 3/4-inch and 2-inch widths, in 1/4-lb and 1/2-lb rolls, respectively. For general splicing work.

SECTION 2. INSTALLATION

2.1 GENERAL INFORMATION

The installation of outside plant (cable) for Mercury application involves:

a. The placing of

(1) Multiple drop wire and terminals

(2) Buried cable in trenches and backfill

(3) Underground cables in conduit and manholes

b. The splicing of

(1) Synchro cable

(2) Plotboard cable

(3) Communications cable with splice cases

c. The termination of these cables at

(1) Post at hardstand locations

(2) Building terminals

(3) CDF (frame)

2.2 PLACING CABLE AND WIRE

2.2.1 Placing Multiple Drop Wire

2.2.1.1 *Attachments*

In planning multiple drop wire runs on building walls, observe the following:

a. Select a location for the first attachment, which will keep the drop wire clear of trees. In some cases, an adjacent building may be used for the first attachment as a means of avoiding trees.

b. Locate ring runs with a view to permanency and accessibility. Avoid runs requiring the use of long ladders.

c. Make all runs horizontal or vertical in so far as practicable. Horizontal runs should be placed out of reach of the public, particularly children.

d. Locate wire runs with a minimum of obstructions.

(1) *First Building Attachment*—Use a drop wire hook as the first building attachment for multiple drop wire in pole-to-house spans. Attach hook to masonry walls with 5/16-inch x 1-3/4-inch hammer-drive anchor, and to wood, stucco on wood, and metal on wood walls with No. 18 RH galvanized wood screw 2-1/2 inches or longer. The screw must penetrate the house studding at least 1-1/4 inches. Only one multiple drop wire should be supported on a drop wire hook.

(2) *Second Building Attachment*—Clamp the cable to the wall close to the drop wire hook attachment with a No. 9 cable clamp. Attach clamp to walls as follows:

Wood walls—1-1/2 inch, No. 14 galvanized RH wood screws

Masonry walls—1/4-inch x 1-inch, hammer-drive anchor

Stucco on wood	
Metal on wood	2-inch No. 14 galvanized
Rigid composition	RH wood screw

(3) *Intermediate Building Attachments*—Use 5/8-inch drive rings spaced about 3 feet apart, as intermediate attachments. It is necessary to spread the opening in the rings slightly in order to insert multiple drop wire.

(4) *Last Building Attachment*—Place a No. 9 cable clamp on the multiple drop wire 6 inches from point of entrance to protector, wire terminal, or building after pulling the wire taut in the ring run. Attach clamp to wall as indicated under Second Building Attachment. (See Figure 2-1.)

e. Install the clamp on the wire in the following manner:

(1) Interlock the two shells on the wire, with the large ends toward the span.

(2) Press the shells together and slide the wedges into the tab rails on the sides of the shells. Tap the wedges with pliers to seat them firmly.

(3) Place the tail wire over the drive hook or drop wire hook.

(4) Complete assembly as shown in Figure 2-1.

2.2.1.2. *Termination*

The multiple drop wire may be terminated in 6-pair wire terminal or 6-pair protector on the outside wall or inside the building.

Remove the outer jacket and glass-yarn tape back to the first of the three drive or bridle rings associated with a pole or wall-mounted terminal. For sheath mounted terminals, stop jacket at terminal-wiring ring nearest the pole. Fan out the pairs, run them through the rings, and terminate them in the terminal in the manner followed for block wire.

The 116A protector is equipped with a housing which is similar to that of the 10 pair N-type distribution terminals. Mount the protector on walls in manner prescribed for N-type terminals.

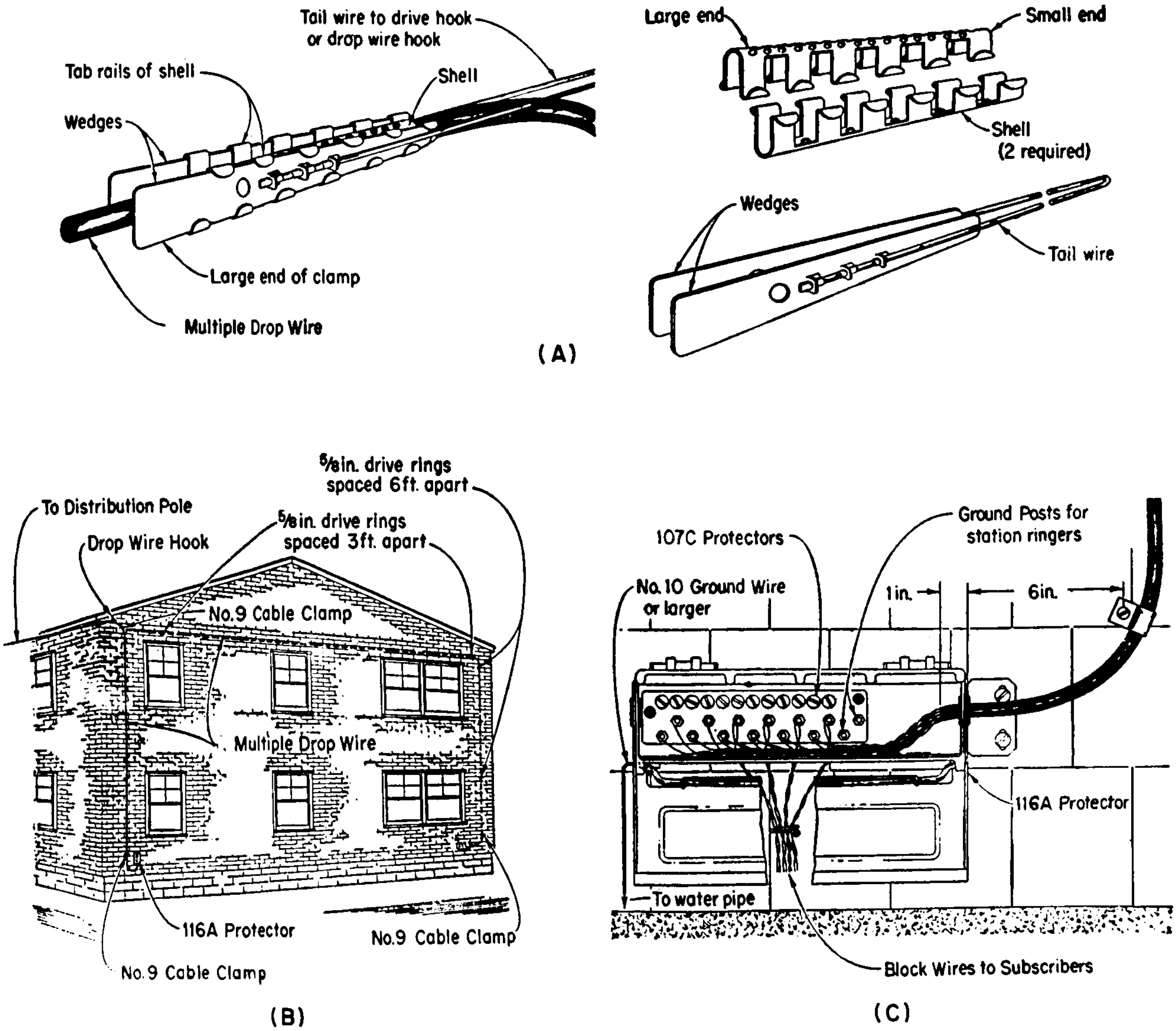


FIGURE 2-1. ATTACHING DROP WIRE

Insert the multiple wire into either end of the protector as desired. It will greatly facilitate conductor terminations, if the end of the multiple wire is stripped of its outer jacket before inserting the wire into the protector housing.

Terminate the conductors under the bottom nut on each binding post. The individual drop or block wires entering the protector through the wire holes are terminated between top and bottom nuts on the binding posts. (See Figure 2-1.)

A 6-pair 104A wire terminal, similar in design to the 116A protector, is used where station protectors are not required. The terminal block is similar to the block in the 116A protector except for the omission of 107C protectors and ground clamp. The wiring of the wire terminal will be the same as for the 116A protector except that the ground-wire connection, when required for station ringers, is made on one of the ground posts. Use a No. 14 ground wire for this purpose.

2.2.1.3 *Miscellaneous Installation Notes*

In order to obtain secure attachments and to avoid damage to building surfaces, it is essential that the specific instructions covered in this section of the practices for each type of surface be followed. Of particular importance are the clearance and lead holes for wall fasteners and fixtures, as means for preventing wall damage.

In general, the same methods apply in making attachments to masonry and substantial brick veneer. Veneering may be considered substantial, where its thickness is at least 3-3/4 inches (as observed at an outside corner), the bricks are joined firmly by the mortar, and indications are that no trouble will result from making attachments in the manner specified for masonry. If there is any question as to whether the veneering is substantial, follow the methods specified for thin-wall brick veneer. On masonry and substantial brick veneer, drill holes for all attachments as close to the center of bricks as practicable and exercise care to avoid damaging and loosening the bricks. In the case of face brick or ornamental types of brick, holes for intermediate and last attachments must be drilled in the seam to avoid breakage, if secure attachments can be obtained.

Clearance holes for fasteners or screw-type fixtures which pass entirely through surfaces such as the seams of bricks, stucco, hollow tile, rigid composition shingles, and lead holes in wood must be provided in accordance with the information in the following listing and associated notes.

Fastener or Fixture	*Size of Clearance Hole or Drill*	*Size of Drill for Lead Hole*
3/16-inch toggle bolt	1/2 inch or 5/8 inch	
1/4-inch toggle bolt	5/8 inch or 3/4 inch	
5/16-inch toggle bolt	5/8 inch or 7/8 inch	
S- and L-type insulated-screw eyes	3/16-inch x 5-1/2-inch installer's drill or No. 12 or 3/16-inch carbon-steel twist drill	3/32-inch drill point or No. 42 or 3/32-inch carbon-steel twist drill
A- and C-type bridle rings		1/8-inch drill point or No. 30 or 1/8-inch carbon-steel twist drill
E-type bridle ring		3/32-inch drill point or No. 42 or 3/32-inch carbon-steel twist drill

(Continued)

Fastener or Fixture	*Size of Clearance Hole or Drill*	*Size of Drill for Lead Hole*
5/8-inch and 7/8-inch drive rings		3/32-inch drill point or No. 42 or 3/32-inch carbon-steel twist drill. Do not drill lead hole in poles.
1-1/4-inch drive ring		11/64-inch drill point
5/16-inch angle screw	5/16-inch x 7-1/2-inch installer's drill or 5/16-inch carbon-steel twist drill	11/64-inch drill point or No. 18 or 11/64-inch carbon-steel twist drill
3/8-inch angle screw	3/8-inch x 8-inch installer's drill or 3/8-inch carbon-steel twist drill	1/4-inch x 6-1/2-inch installer's drill or 1/4-inch carbon-steel twist drill
No. 10 wood screw	3/16-inch x 5-1/2-inch installer's drill or No. 12 or 3/16-inch carbon-steel twist drill	3/32-inch drill point or No. 42 or 3/32-inch carbon-steel twist drill
No. 14 wood screw	1/4-inch x 6-1/2-inch installer's drill or 1/4-inch carbon-steel twist drill	1/8-inch drill point or No. 30 or 1/8-inch carbon-steel twist drill
No. 18 wood screw	5/16-inch x 7-1/2-inch installer's drill or 5/16-inch carbon-steel twist drill	11/64-inch drill point or No. 18 or 11/64-inch carbon-steel twist drill

NOTES

1. Installers' drills are bit-stock, twist drills and are used in the ratchet brace.
2. Carbon-steel twist drills are straight-shank drills and are used in the hand drill.
3. Drill points are used in the automatic drill and will drill lead holes approximately 1-1/2 inches deep. Where deeper holes are required, use twist drills in the hand drill.
4. Use L-type masonry drills for drilling the seam between bricks.
5. Use L-type masonry drills or star-faced stone drills in drilling holes for toggle bolts. Two sizes of holes are listed to cover the different types of approved toggle bolts. Drill the smaller hole, if it will accommodate the toggle bolt.
6. Apply paraffin, wax, or soap to the threads of wood screws or screw-type fixtures to facilitate turning them into wood.

2.2.2 Placing Buried Cables—All Types

The three types of cable used at Mercury sites (synchro, plotboard, and communication) may be buried in the same trench, where required. Specific instructions for the burial of cable is given on the -360 and -361 site drawings associated with each installation.

2.2.2.1 *Trenching*

The method of trenching preparatory to placing buried cable depends on the soil conditions, the topography of the ground, the route, and the apparatus available. The trench may be dug either by machinery or by hand, or the cable may be placed by a specially designed plow. In general, the plow will be used for the longer cables, machine trenching for the shorter cables, and hand trenching for short sections, such as laterals and service cables.

The trench should be as narrow as practicable to avoid unnecessary handling of earth. When the trench is dug by hand, the operations may be facilitated by the use of an agricultural or grading plow to excavate the top portion of the trench.

When the route of the cable passes under shrubs, sidewalks, paved streets, etc, it may often be found advantageous to push or drive a pipe, instead of opening a trench. The pipe may be removed after the cable is placed, unless the mechanical protection of the pipe is required.

When it is necessary to remove pavement, the paving material should be kept separate from other excavated materials so that it may be reused, if practicable. Do not remove more pavement than is necessary.

Buried cable should ordinarily be installed so that a coverage of 24 to 36 inches will be obtained. In fields, the coverage should be adequate to permit agricultural operations to be carried on without disturbing the cable.

When crossing unimproved roads, streets, and alleys that may later be paved or hard surfaced, the trench should, where practicable, be so located and of such depth, that proper coverage for the cable will remain after the permanent grade has been established or other improvements have been made. In general, the depth of placing at such points must be shown on the detail plans.

At splice locations, it is necessary to provide an excavation sufficient in size for the splicing operations specified on the detail plans. These excavations may be made at the time of the other trenching operations or they may be considered a separate part of the project. The types of splicing pits that may be used are shown in the section covering buried cable splicing.

The lengths of sections of buried cable depend upon the conditions encountered on the particular project. In general, the location of the splices is given on the detail plans and the best length of section to meet these locations and the placing conditions on the job should be used.

Splice points on the shorter cables will usually fall at the location of manholes, handholes, branch cable junctions, or terminals. If terminals are located at frequent intervals, a single length of cable can extend through several terminal locations. There are also conditions, especially on the longer cables, that necessitate splices at locations other than those indicated. Such locations will require making a buried splice.

2.2.2.2 *Placing Buried Cable*

When the trench is free from obstructions and the nature of the soil is such that the sides of the trench will not cave in, the cable may be placed direct from a reel mounted on a trailer which is pulled along over the trench. The trailer may be pulled by a separate unit or attached directly to the trenching machine. If the ground is reasonably level and the equipment is available, time may be saved by attaching two trailers, laying the cable from the rear reel first and then passing the cable from the front reel over the drum of the rear reel into the trench. A man must follow closely behind the trailer to see that the cable does not stick on the reel and that it lies reasonably flat along the bottom of the trench. When this method is used, it becomes necessary to secure the end of the cable until the weight of cable removed from the reel is sufficient to hold it in place at the point of overlap with the preceding section.

There may be locations where, due to obstructions or other local conditions, it is desirable to pull the trailer along beside the trench and have the cable guided into the trench by hand.

Where there are steep grades, gullies, fluid-soil conditions, or obstructions such as streets, roads, pipe lines, etc., it may be necessary to pull the cable into the trench from a reel located at the end of the cable section or at some intermediate point. Where this method is applied, trench rollers or other supporting devices must be used unless the section is short. The rollers must be spaced at intervals so that any dragging on the bottom of the trench will not damage the protective coverings nor result in an excessive pull on the end of the cable.

There may be conditions where it is advantageous to use a combination of the placing methods described above. Where this is done, the procedure outlined for each of the methods should be followed for the portion to which it applies.

At crossings, the relative levels, protection, and separations between buried cables and foreign structures must be as follows:

a. Buried cables may be placed either above or below gas or water mains and services, or ducts carrying power cables. Buried telephone cables must be placed above buried power cables and below pipe lines carrying petroleum products, where practicable.

b. Where buried telephone cable crosses above gas, water, or oil mains or services, the cable should be protected from digging operations by concrete or treated wood planking for at least 3 feet each way from the point of crossing. At all crossings of buried telephone and power cables, the cable in the top position must be protected from digging operations in a similar manner.

c. Separations from foreign structures, such as gas, water, or oil mains must be at least 6 inches of well-tamped earth or 3 inches of concrete.

d. Separations from ducts containing power cables must be at least 12 inches of well-tamped earth or 3 inches of concrete.

e. Separations from buried power cables with or without metallic sheath must be at least 12 inches of well-tamped earth or 3 inches of concrete as shown in the following figures. Where concrete is used at crossings, it must be at least 3 inches by 4 inches in cross section and must extend along the power cable on both sides of the point of crossing to points at least 12 inches away from the telephone cable. (See Figure 2-2.)

When the pedestal is to be installed after the cable is placed, the ends of the cable or the loop, as the case may be, should be left so that it is protected as much as practicable. In some cases, it may be desirable to place the ends in the trench and cover them with a small amount of backfill.

If the pedestals are installed in advance of or at the time the cable is placed, the cable should be lashed to the pedestal as shown, unless additional protection is required, in which case the exposed cable must be placed in the trench and covered. (See Figure 2-2.)

The end of the buried cable section terminating at a pole should be extended up the pole as shown and should be protected with a cable guard of the proper size. Sufficient length of cable must be left to make the necessary connections. The location of the splice depends on the particular conditions at the pole. (See Figure 2-2.)

NOTE

> When buried cable is placed, sufficient overlap must be provided at splice points to make the splice. The average overlap at poles, buried splices (pits) and manholes is 3 feet. At pedestals, 7 feet of cable must be left in a loop.

2.2.2.3 *Backfilling*

Backfilling may be done by hand or by machinery, depending on local conditions and the apparatus available. The general features of this work will be the same for any procedure.

The trench and the space outside the walls of manholes must be backfilled as soon as practicable. It is, of course, desirable to leave the

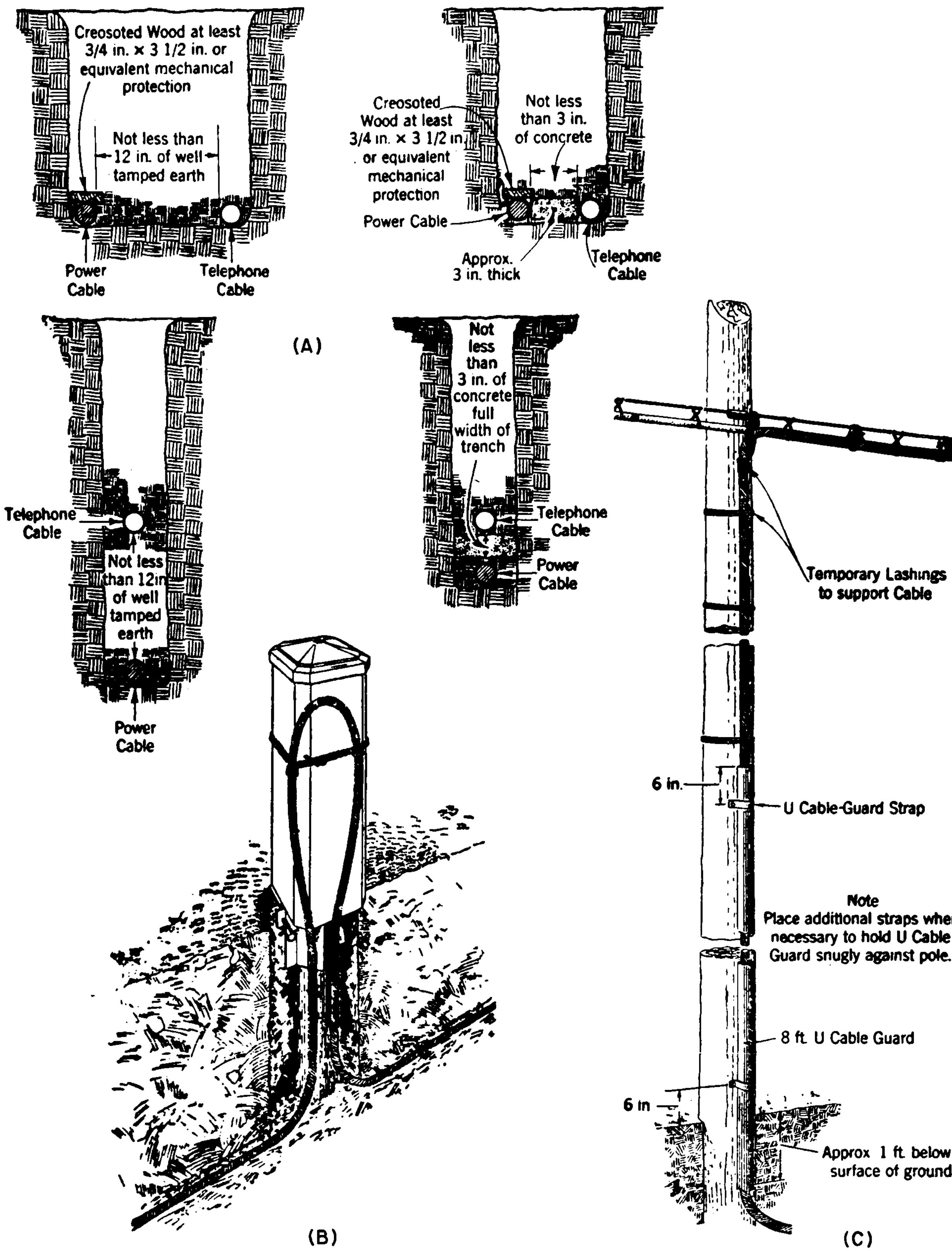


FIGURE 2-2. BURIED CABLE

excavations open at splice points and buried manholes, until all splicing and testing work has been completed. Under some conditions, however, there may be objections to leaving the splice points open for this length of time. In such cases, it becomes necessary either to backfill temporarily or cover them with planking. Before a splicing pit is temporarily backfilled, a plank or some other form of mechanical protection should be placed over the cable to facilitate the re-excavation.

The backfilling must conform to local regulations, if any are in effect for the particular locality. The work must be done in a manner that will minimize the maintenance of the route and maintain the coverage of the cable.

2.2.3 Placing Underground Cables—All Types

Some underground cable plants with conduit and manholes will be installed for Mercury application and the manholes will be of concrete construction. The conduit is transite (concrete).

2.2.3.1 *Manholes and Conduit*

The specifications for the manholes are given on the -360 and -361 site drawings (Bermuda, Canton Island, and Hawaii). Figure 1-7 of Section 1 shows a typical type-B manhole and transite (cement) conduit. The component parts are listed and described in paragraphs 1.4.2.6 and 1.4.2.7 of this manual.

2.2.3.2 *Miscellaneous Installation Notes*

At the time the manhole is constructed, concrete inserts should be placed in the walls for the attachment of the ultimate number of cable racks or cable-rack supports needed in the manhole. Generally, however, only the racks and rack supports required for immediately planned cable installations, will be provided initially.

Secure the supports to the walls by means of 1/2-inch x 2-1/2-inch galvanized machine bolts screwed into concrete inserts which will generally be cast in the walls when the manhole is constructed. If inserts have not been placed, drill holes for 1/2-inch expansion shields at the proper locations, using a 7/8-inch drill. Make the attachment by means of a 1/2-inch x 2-1/2-inch galvanized machine bolt and the expansion shield.

Pulling-in irons are installed for the purpose of providing a point of attachment for blocks, sheaves, and other tackle employed in the installation and maintenance of cable.

Two types of pulling-in irons are available, the No. 1-type for brick walls and the No. 2-type for walls constructed of concrete. Both pulling-in irons are designed to extend into the manhole far enough to permit a clear opening of approximately 3 inches in the eye, as shown below. This work must, of course, be done in conjunction with the wall construction, as explained in the respective sections.

With a 6-inch concrete wall or 8-inch brick wall, the vertical legs of the irons bear against the outside face of the wall. For heavier walls, the legs are embedded in the concrete or mortar of the wall.

In general, one pulling-in iron is to be placed in the wall opposite each duct entrance, usually at a point from 6 to 12 inches below the ducts with which they are associated and in line with the center line of the duct or bank of ducts. On occasion, it may be desirable to place additional irons above the duct banks, depending upon the cable-pulling requirements of the particular entrance.

2.2.3.3 *Pulling-In Underground Cable (Figure 2-3)*

Use the cable feeder to protect the cable and to guide it into the duct. The main or longer section of the cable feeder fits into the nozzle which is placed in the duct; a 3-inch nozzle is used with 3-inch round-bore conduit, a 3-1/4-inch nozzle for general use with 3-1/4-inch square or 4-inch round-bore conduit, and a 3-1/4-inch S-type nozzle for use with maximum size polyethylene-sheathed or corrosion-protected cable in 3-1/4-inch square conduit. Where an extension section of the cable feeder is also required, its nozzle end must be fitted into the bell end of the main section.

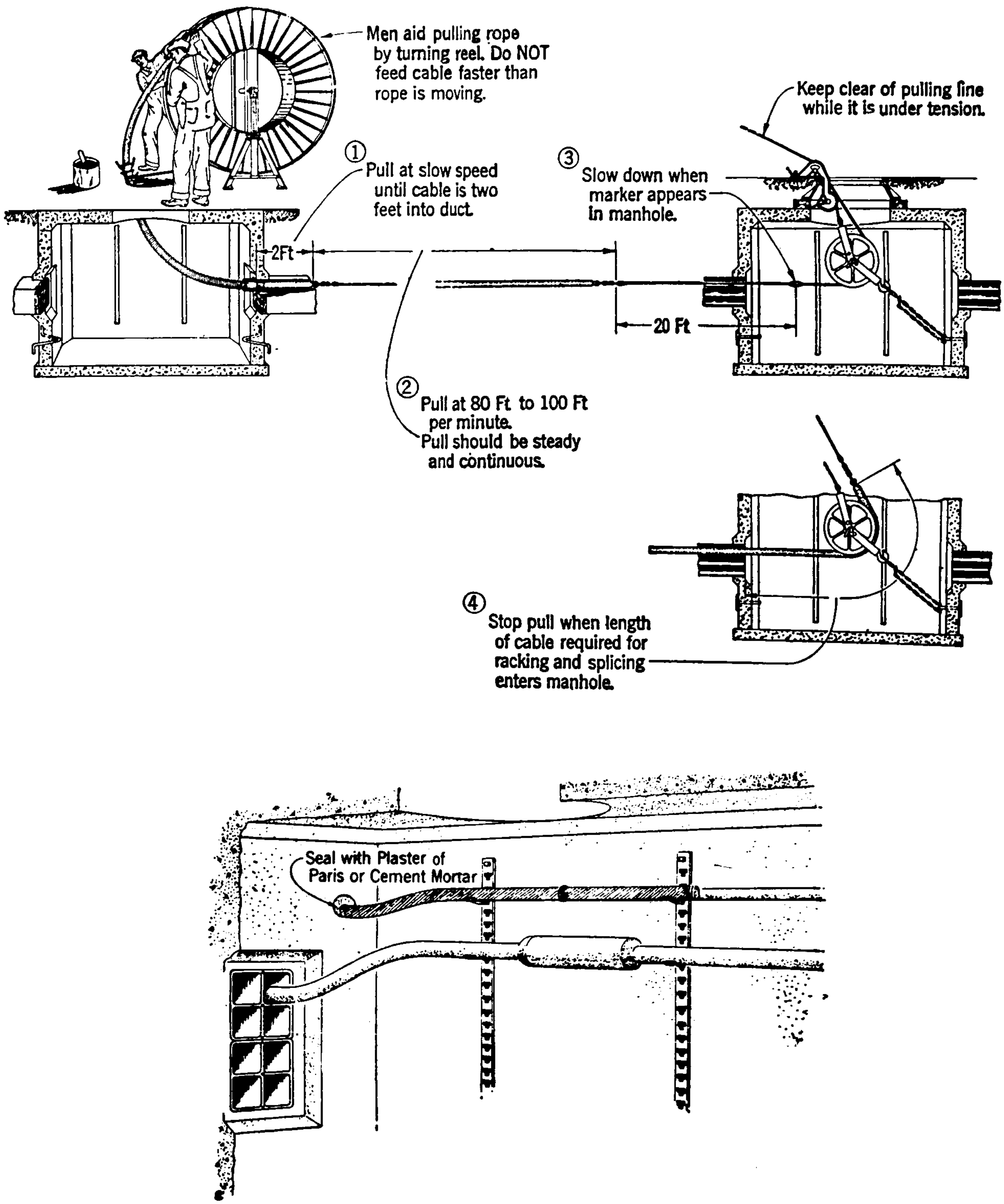


FIGURE 2-3. SEALING DUCTS AND MANHOLES

Thread the pulling line from the duct through the cable feeder. Where the cable lubricator is used, thread the pulling line through it before the connection is made between the line and the cable.

Lubrication is not necessary on lengths shorter than 300 feet, provided that the section is free from sharp bends. Otherwise the cable should be lubricated with B- or C-type cable lubricant, and with no other lubricant.

Soap lubricants or lubricants containing soap are definitely harmful to polyethylene sheath. If soap has been used in quantity in a previously occupied duct, and no duct free from traces of soap is available, polyethylene sheath must not be used at this location.

With the exception of B- or C-type cable lubricant, other lubricants that do not contain soap must be kept away from polyethylene sheath as much as possible. The inside of the cable feeder must be wiped free of excess lubricant before using it. Polyethylene should only be placed in a previously occupied duct when no duct free of lubricant is available. If the deposit of lubricant has been heavy, swab the duct to remove as much of the lubricant as possible before placing the cable. After placing, wipe the exposed cable with a clean cloth before leaving the manhole.

Lengths of cable up to 1000 feet or more, including two or three intermediate manholes, can be pulled with some additional preparations.

After the ducts have been selected and properly cleaned, adequate lubrication and steady pulling are required. The cable lubricator should be used at the feeder manhole and the amount of lubricant passed through it should be increased 5 pounds per 100 feet.

At intermediate manholes, guide the leading end of the cable into the duct. When it has entered the duct, place a feeder-tube nozzle around the cable and slide it into the duct entrance to keep the cable from rubbing on the edge of the duct.

Tighten the nut on the pulling eye of polyethylene-sheath cables with a wrench, after a hard pull to maintain pressure on the sealing gasket.

Leave enough cable in one or both end manholes to give the slack required to rack the cable at intermediate manholes, plus the length needed to rack and splice the cable at the end manholes. The additional length required for slack at intermediate manholes is the bent length of a flexible rule in the set-up position to be occupied by the cable, minus the straight length of the cable.

Measure the cable ends in the manholes to make sure that they agree with the lengths shown on the running sheet or print. If the lengths do not agree, measure the length of the conduit section and advise your supervisor.

After the measurements have been made, cable ends not equipped with pulling eyes or core hitches must be tapped with a hammer to make sure that the sheath has not been stretched beyond the end of the core, leaving the wires too short for splicing. Examine all pulled ends for evidence of cracks or openings, due to beating rings into the sheath or to damage in pulling, and take steps to seal any such openings.

2.2.3.4 *Sealing Ducts and Manholes*

When a buried cable enters a manhole of an underground conduit system, the cable should be brought in through the wall, preferably at the end of the manhole. The entrance must be sealed with cement mortar or with a mortar made from equal parts of plaster of Paris and sand. The protective covering must extend into the manhole for at least three inches, so that the mortar will not come in contact with the lead sheath. (See Figure 2-3.)

a. *Solid Rubber Plugs*—Solid rubber conduit plugs are available as illustrated. Individual parts of all plugs can be obtained for replacement purposes. (See Figure 2-4.)

Seals which are required to remain tight against gas or water pressure, should be made with either rubber conduit plugs, waterplug or B-type duct sealer, depending on conditions. Rubber plugs are available for all sealing conditions except round-bore ducts occupied by the larger sizes of cables. For the latter cases and in situations where rubber plugs cannot be used, waterplug or B-type duct sealer must be employed. When requirements are less exacting, plastic duct seal or wood conduit plugs can be used.

Plastic duct seal must not be used to seal ducts containing alpeth cable or any cable having polyethylene as the outer covering. In such cases, substitute waterplug, B-type duct sealer or rubber conduit plugs in situations where the instructions specify plastic duct seal.

Existing seals made with materials other than those included in these instructions need not be replaced, if they are performing satisfactorily. When it becomes necessary, however, to remove such seals in the course of other work, a replacing seal of approved type should be used.

Before replacing old seals or applying seals at new cable installations, remove all old material such as oakum, muslin, cotton waste, paper, etc., that may be in the duct.

All ducts entering central offices or other buildings must be kept sealed at all times, except when it is necessary to have them open for construction or maintenance work. If the work extends over several days, all seals must be replaced temporarily at night. As soon as the work requiring their removal is completed, the seals must be replaced permanently and inspected carefully to see that they are tight.

Upon completion of other work on cables in manholes, cable vaults, or buildings, examine for leakage and restore or replace any seals that may have been weakened as the result of cable movement during the course of the work.

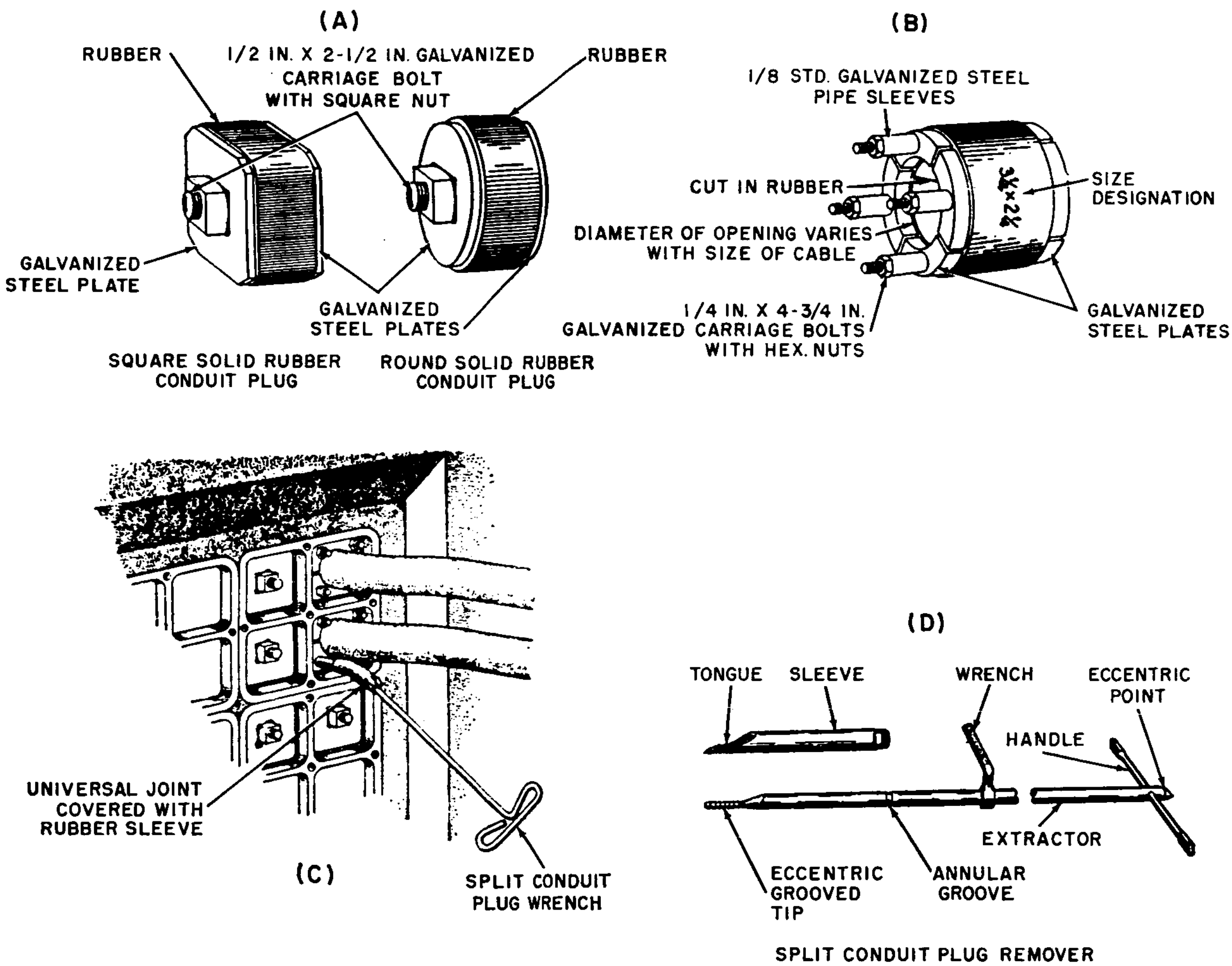


FIGURE 2-4. RUBBER PLUGS

Do not attempt to use for seals in buildings, rubber conduit plugs, the rubber of which has hardened to a degree which prevents it from expanding readily. Replacement rubber parts should be obtained for such plugs which are otherwise in good condition. This will apply mainly to plugs which have been in service previously in dry locations or which have been in storage for long periods.

To extract the solid plug, first back off the nut a few threads to relieve the compression in the rubber. The plug can then usually be withdrawn. If relieving the pressure does not restore the rubber to its original size or if it adheres to the walls of the duct, it becomes necessary to apply force to the plug to work it loose. This can be done either by unscrewing the nut until about half the threads in the nut are exposed and screwing another bolt into the exposed threads to act as a handle, or by twisting a piece of steel-construction wire under the nut to which a prying lever can be attached.

b. *Split-Rubber Plugs (See Figure 2-4)*— In the split rubber conduit plug, the rubber portion of the plug is molded to fit around cables of varying diameters. The plug has a diagonal cut in one wall to allow it to be placed over the cable and is furnished with sectional plates shaped to conform to that of the plug. Compression of the rubber is accomplished by means of four 1/4-inch carriage bolts which extend through the plates and the rubber portion of the plug, as illustrated. Split rubber conduit plugs are available in the square type for all sizes of cables and in the round type for all situations where approximately 1/2 inch or more annular space remains between the cable and the duct wall. Individual parts of all plugs can be obtained for replacement purposes.

Plug sizes are designated by duct dimension and the nominal diameter of the largest cable for which the plug is designed. Each plug is adaptable to a range of cable sizes as indicated in the tables following. The plugs possess sufficient flexibility to permit some overlap of ranges, so that a plug designed for a certain range of cable diameters frequently can be used on the larger cables of the next-lower range and on the smaller cables of the next-higher range. As an example of the way in which this flexibility can be used to advantage, if difficulty is encountered in obtaining a seal with the plug of indicated size, try the next smaller size to make use of the increased expansion provided by the heavier wall thickness.

Before installing split rubber conduit plugs, examine the duct and remove any rough spots or accumulations of grease or silt. Inspect the cable for kinks just inside the duct, as the existence of such kinks will determine to some extent the depth to which the plug is to be placed in the duct. Minor indentations of the sheath will be sealed by the plug, but when deep kinks are found, it may be necessary to place the plug beyond the kink or to use an alternative method of sealing to obtain water-tightness.

Inspect the split rubber conduit plug to see that the parts are properly assembled, with the nuts all in the same end and with the split in the rubber covered by a section of metal plate at each end. Examine the nuts to see that they are free and not compressing the rubber.

To place a square split plug on a cable, remove one of the bolts holding the plates covering the split in the rubber. Swing these plates on the other bolt to uncover the split in the rubber. Spread the rubber as illustrated and slip the plug over the cable with the nuts facing outward.

Restore the plates to position and replace the bolt and nut. When the cable is out of round, place the plug so that the openings between the end plates are in line with the short diameter of the cable. This same procedure should be followed when the bend in the cable extends into the duct.

Tighten the nuts with the split conduit plug wrench illustrated, turning down each nut a little at a time so as to keep the pressure as uniform as possible on all sides. Too much tightening of one nut may displace the cable to one side and make access to the remaining nuts difficult. (See Figure 2-4.)

The split conduit plug remover consists of three parts, sleeve, extractor, and wrench, as illustrated. (See Figure 2-4.)

c. *Plastic Duct Seal*

Plastic duct seal is a putty-like compound which retains a degree of plasticity in service with only a slight tendency toward stiffening of the surface exposed to the air. It is suitable for sealing ducts which are dry at the time of application and which will not be subject to appreciable pressures of long duration. It must not be used to seal around alpeth or any other polyethylene-sheath cable. It is supplied in 1 pound and 5 pound packages and is ready for use as received.

At 20° F and lower, plastic duct seal stiffens and loses tackiness to some degree. When working at these temperatures, the workability of the material improves if it can be stored in a warm place until just before it is used.

Before applying duct seal, make certain that the duct opening is dry and that all loosely adhering material, grease or paraffin, has been removed.

In sealing cables in a vertical position as in bends at poles or at the top of riser pipes, roll a quantity of the material between the hands to form a rope slightly larger in diameter than the space to be filled between cable and duct. Wrap the material around the cable and, while holding the cable centered in the duct, force the duct seal into the duct to a depth of about 2 inches. Apply successive lengths of the material, forcing them firmly into position until the space is sealed at the top of the duct. Bevel the top seal, sloping slightly upward from the edge of the duct to the cable.

In sealing cable in a horizontal position, apply a wrapping of lead tape to center the cable in the duct. Place the tape 2 inches in from the face of the duct and apply duct seal as described above.

Vacant ducts should be sealed by first forming a backing of paper or waste set about 3 inches back from the face of the duct. The remaining space should be filled with duct seal, working the material firmly against the walls of the duct. Later, when cable is installed in the duct, the backing material must be cleaned out and discarded. The plastic duct seal removed from the duct can be reused to seal around the cable.

2.2.3.5 *Marking Cable Routes*

Markers may be either wood or concrete. They are used to establish the location of the buried-cable route and, when equipped with signs, serve as a warning that cables are present. They may also be used for mounting electrolysis-test wires, pressure contactors, pressure-testing valves, and test terminals.

The concrete markers present a good appearance and are fireproof. The wood markers withstand considerably more shock and impact such as experienced when struck by farm machinery, but they are more susceptible to damage by fire. The type of marker and length is specified in the detail plans.

The posts supplied on the Mercury installation are of concrete and are 4 inches square and 4 feet long. (5-inch square-wooden posts may be substituted.)

The markers shall be located at splice locations, points of route changes, on each side of roadway crossings, and at reasonably spaced intervals in a straight cable run.

Final locations of all cable markers must be shown on the field copy of the cable print.

2.3 SPLICING CABLE

2.3.1 General Information

Three types of cable (communications, synchro, and plotboard) are included in the Mercury installations. As the splicing procedures for each of these cables differ somewhat, they are discussed separately in the paragraphs which follow.

In all cases, the splicing is done in a pit where buried plant is employed and in a manhole of the underground system. Splice cases are used in connection with the communications cable, as this is polyethylene-sheathed cable.

All conductors must be soldered at each splice point.

In using rubber conduit plugs for sealing cables having jute or fabric coverings over the sheath, it is not necessary to remove the protection in order to obtain a tight seal. In selecting the size of plug, obtain the cable diameter over the protection and use this figure as the cable diameter in the tables of plug sizes appearing in the section relating to split rubber plugs.

Dowel-pin holes, cracked conduit walls, or porous areas in the masonry adjacent to conduit entrances afford a means for gas or water to enter and must be filled, if it is desired to seal the structure permanently. Waterplug can be used for this purpose, following the instructions for using this material to seal ducts.

Remove any dirt, grease, or loosely adhering material from the duct end and from the surfaces of the plug. With the bolt and washers in place, insert the plug into the duct with the nut outward and to a depth such as to afford the best bearing surfaces and permit effective use of the wrench in tightening the nut. The plug must be inserted far enough into the duct to clear the bevel and beyond any large cracks or chipped areas that may exist in the walls or webs of clay conduit.

Using the lineman's wrench or any other wrench suitable for use with a 1/2-inch nut, turn the nut until the rubber is expanded firmly against the duct walls. Excessive tension must not be applied, since extreme pressure (causing the rubber to bulge out around the edges of the washers) is usually unnecessary and, in the case of clay conduit, may crack the walls.

2.3.2 Splicing Communications Cable

2.3.2.1 *Basic Precautions and Rules*

a. All splices must be carefully planned so that they will be properly located for the splicing operations and properly supported and protected during splicing. Measurements for layout of splices must be made carefully to avoid unnecessary removal of protective coverings and to simplify protection during and upon completion of the work.

b. Detail work prints are generally issued for most splicing jobs. These must be studied carefully to determine the sequence of operations to be performed.

c. Avoid excess heat when working with polyethylene insulation. This insulation begins to soften at 175° F and melts at about 230° F. A mechanical bond to the aluminum is specified to avoid a soldering operation.

d. Determine the size and type of splice case to be used so that the amount of sheath opening can be accurately determined. This is discussed further in paragraph 2.3.2.3 in connection with splice cases and sheath openings.

e. Protect the splice while it is incomplete so that moisture will not enter it.

When working in a manhole, place a tarpaulin or approved equivalent over the manhole wall in back of the splice, so that the insulation on the conductors will not absorb moisture from the wall. If necessary, hang a tarpaulin or a rubber blanket across the roof of the manhole to keep drippings from the street or the manhole roof from falling on the splice.

It is essential to protect the splice with a tent, tarpaulin, or other covering during inclement weather.

C- and D-type splice covers may be used for temporary protection of new uncompleted straight and branch splices respectively, where the cable is likely to become submerged. Their installation is discussed further in paragraph 2.3.2.7.

f. It is important that the required splicing supplies are on hand prior to making sheath openings. (See material list in paragraph 2.3.2.2.)

2.3.2.2 *Splicing Materials*

The standard splicing supplies are listed below for the convenience of the splicer, in checking the available materials and the quantities in which they can be obtained. Some major items have been previously discussed in paragraph 1.4 of this manual and materials which have only limited application are listed in the section where the item applies.

Item	*Description and Use*
Anchor, drive, hammer	1/4 inch x 1 inch. For attaching cable clamps and straps to masonry.
Cement, C	Supplied in 4-ounce bottles with dauber. About one-half ounce needed per splice.
Clamp, cable	Available in various sizes. For clamping cables and sleeves to masonry and wood.
Clamp, ribbon, bonding	For attaching bondings ribbon to manhole walls.
Cloth, wire, B	Wire cloth 2-inch wide. Supplied in packages containing 20 pieces, 2 inches wide x 12 inches long. About 2 pieces needed per splice. For making joints in alpeth-sheath cable.
Cord, rubber, gum	1/8 inch in diameter. Available in 50-foot coils. For making wrapped joints gas tight.
Covering, splice, D	Supplied in pieces, 20 inches x 24 inches. For protecting temporary openings in cables.
Desiccant, B	Available in 160- and 650-gram containers. For drying conductor insulation.
Disc, splice, multiple	Available in various sizes. For maintaining separation between cables at multiple joints.
Hook, cable	Available in 4-inch, 7-1/2-inch, and 10-inch lengths. For supporting cable in manholes.
Houseline	Available in 1-lb and 5-lb balls and in 10-lb coils. For supporting cables temporarily.
Muslin	Supplied by the yard in 36-inch widths. Also available in a 2-inch width (4 to 6 yards long), and in a 4-inch width (7 to 10 yards long). The 36-inch width is used for wrapping splices and ventilating manholes. The 2- and 4-inch widths are used for wrapping splices.
Nails, strap	Available in sizes 3/16 inch x 1-1/2 inch and 3/16 inch x 2 inch. For attaching cable clamps and straps to wood.
Paint, asphalt, No. 2	Available in 1 pt, 1 qt, 1 gal and 55 gal containers. For painting taped openings and splices in buried cable.
Paraffin	Available in 11-lb and 20-lb cakes. For boiling out splices, cotton tape, etc.
Pasters, cable	Available in rolls 1 inch and 2 inches wide in lengths of 60 feet. For limiting the width of wiped joints and soldered seams.
Ribbon, bonding	Supplied by the pound, approximately 17 feet to the pound. For bonding cables.
Screw, wood	Available in 1-1/2-inch and 2-inch lengths. For attaching cable clamps and straps to wood surfaces.
Sleeve, copper, tinned, No. 13-S	For making soldered sleeve joints in cable conductors.

(Continued)

Item	*Description and Use*
Sleeve, copper, tinned, No. 13-D	
Sleeve, copper, tinned, No. 16	
Sleeve, plastic B Sleeves, plastic, filled	Available in various diameters, in cardboard boxes. For insulating twisted joints at splices.
Screw, machine, brass 1/4 inch 8-32	For connecting bond wire to aluminum shield. Two required per splice.
Sleeving, cotton	Available in 1/8-inch, 5/32-inch, 1/4-inch, and 5/8-inch sizes in 1-lb spools for protecting the core from the sheath at cable openings.
Solder, rosin-core	Available in 1-lb and 5-lb spools. For soldering joints in cable conductors.
Strap, sleeve, adjustable	For clamping large sleeves to walls.
Strap, cable	Available in various sizes. For clamping cables and splices to masonry and wood.
Tag, cable, octagonal	For tagging underground toll and trunk cables.
Tag, cable, round	For tagging underground subscriber cables.
Tag, cable, strap	For tagging large underground cables.
Tag, terminal	For tagging terminals and small underground cables.
Tag, warning, B	For tagging sleeves of cables under gas pressure.
Tag, warning, C	For tagging sleeves of cables containing coaxial pairs.
Tag, warning, D	For tagging sleeves of cables containing video pairs.
Tape, aluminum, B	Aluminum tape with adhesive on one side. Supplied in rolls 4 inches wide containing 20-linear feet. About 5 feet required per splice. For making joints in alpeth-sheath cable.
Tape, B	Neoprene tape with one tacky surface. Supplied in rolls 2 inches wide containing 15-linear feet. About one roll required per splice. When 1/2- or 1-inch strips are called for they can be cut from the 2-inch tape. For making joints in alpeth-sheath cable.
Tape, cambric, varnished	Supplied in rolls 1-1/2 inches wide and 25 feet long. For insulating the butt at sheath openings in high-dielectric strength cables.
Tape, cotton	Available in 1/2-inch and 1-inch widths in 2-ounce and 4-ounce rolls, respectively. For protecting the core from the sheath at cable openings.
Tape, CR	Available in 1-inch and 28-inch widths in 20-foot rolls. For use at temporary openings, insulating joints, and for covering splices in buildings.
Tape, electrical, scotch	Available in 3/8-inch and 1/2-inch widths in rolls of 10 yards and 36 yards. For general splicing work.

(Continued)

Item	Description and Use
Tape, electrical, scotch No. 27	Glass cloth tape. Supplied in rolls 3/4 inch wide x 30 feet long. For terminating tape armor and for insulating joints.
Tape, friction	Available in 3/4-inch width in 1/4- and 1/2-lb rolls and in 2-inch widths in 1/2-lb and 1-lb rolls. For general splicing work.
Tape, polyethylene, B	Supplied in rolls 3 inches wide x 100 feet long. For wrapping splices in high-dielectric strength cable.
Tape, rubber	Available in 3/4-inch and 2-inch widths in 1/4- and 1/2-lb rolls, respectively. For general splicing work.
Tape, vinyl, B	Adhesive-vinyl tape 2 inches wide. For wrapping lead sleeves in buried cable.
Tape, vinyl, D	Adhesive-vinyl tape 1 inch wide. For repairing punctured-polyethylene insulation.
Wire, lashing, copper tinned, 16 Ga.	For bonding aluminum to lead sleeve.
Wedge, lead	Available in various sizes. For maintaining cable separation at Y joints.
Wire, lashing, copper	Supplied in 1-lb spools containing 128 feet. For making ties to support cable splices and for attaching cable tags.
Wire, lashing, lead	Supplied in 1-1/2-lb spools containing 90 feet. For making ties to support cable splices and for attaching cables tags.

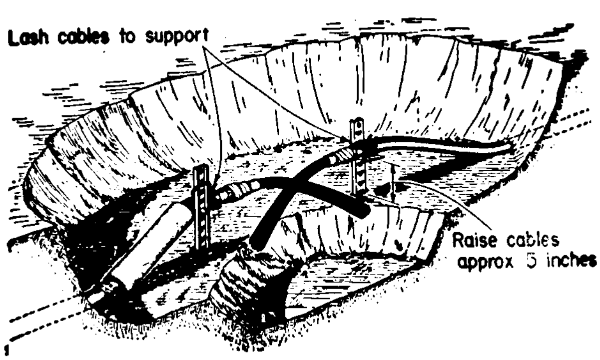
2.3.2.3 *Sheath Preparation*

Extreme care must be taken in removing the protective coverings in order to prevent damage to the sheath and the conductors.

Splices on buried cable may be made in splicing pits dug to a depth which will provide the specified coverage over the completed splices or may be made above ground and then lowered into a trench. In the pit splicing method, which must be used wherever practical, the handling of the cables is reduced to a minimum and there is less likelihood of sheath damage or conductor trouble in the completed splice. However, where digging splicing pits concurrently with splicing work would be impracticable or unduly expensive because of either frozen or fluid soil conditions, which will later be relieved by seasonal changes or where the specified cable coverage would result in unusually deep splicing pits that would require expensive back sloping or shoring to provide safe working conditions, the splicing should be done above ground.

In order to facilitate future maintenance operations, it is necessary to leave slack in the cable at splice points. For large-diameter cables, this should be done by placing an offset in the cable in the splicing pit. Long-radius bends must be made to avoid damaging the cable. The ends may be set-up for splicing by one of the methods given in the following paragraphs.

The following illustration shows a method of setting up the ends of the cable for splicing using a single offset to provide slack in the cable. This method permits using a splicing pit of small area but with the bottom at two different levels. The cable need be raised only a few inches to permit splicing and can be lowered to its final location after splicing with little bending or twisting of the cable. Excavating the splicing pit as shown, permits making the splice near the bottom of the splicing pit and yet the sleeve of the splice can be placed on undisturbed earth for its final location where future settling should be a minimum. To arrange the cables as shown, the ends must be bent in a horizontal plane at the bottom of the splicing pit and then raised about 5 inches to permit splicing. The cable must be held in position by lashing it with houseline to supports (cable rack, 2 x 4's, etc.) of the desired height. The protective coverings and cable sheath must be removed after the ends are set up for splicing.



It is generally helpful to bend a measuring rule in the position to be occupied by the cable between the duct entrance and the end-cable rack, as illustrated below. Note the length and location of each of the two bends and mark these on the cable sheath. Keep the cable straight for a distance of about two inches from the duct entrance before starting the first bend.

The second bend should end just short of the end-cable rack as shown on the following sketch.

In setting up cable, it is important to change the point about which the cable is bent, frequently, so as to distribute the sheath strain along the entire bend. Sharp jerks must be avoided. Otherwise, the strain would be concentrated at one point, causing serious kinks and weakening the sheath at that point.

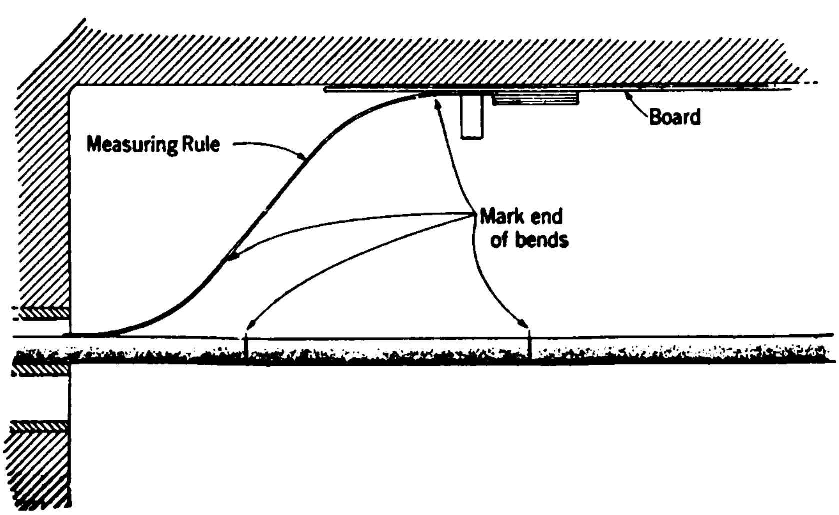
Avoid making sharp bends. In racking a cable, the radius of the bend must be as large as practicable. Bends in the smaller cables may be of smaller radius, depending upon the size of the cables. Do not flatten or kink the cable. Dress out any kinks or irregularities in lead sheath with a cable dresser, being careful not to weaken the sheath. Cable bending can best be done by exerting a slow, steady pressure. A sharp jerky push or pull usually results in kinking the cable.

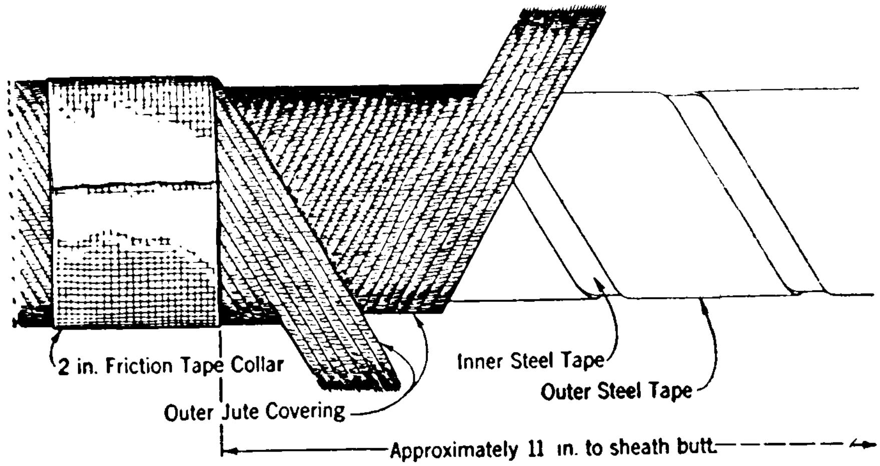
The use of a cable bending shoe placed in the mouth of the duct will help in making the proper bend.

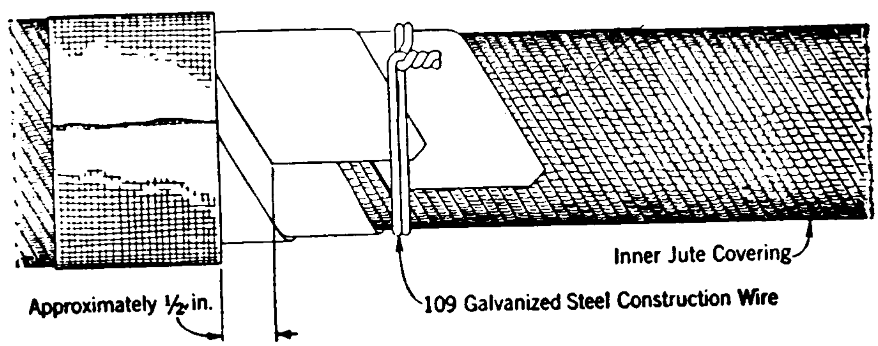
a. *Removing Outer Protection and Opening Sheath*

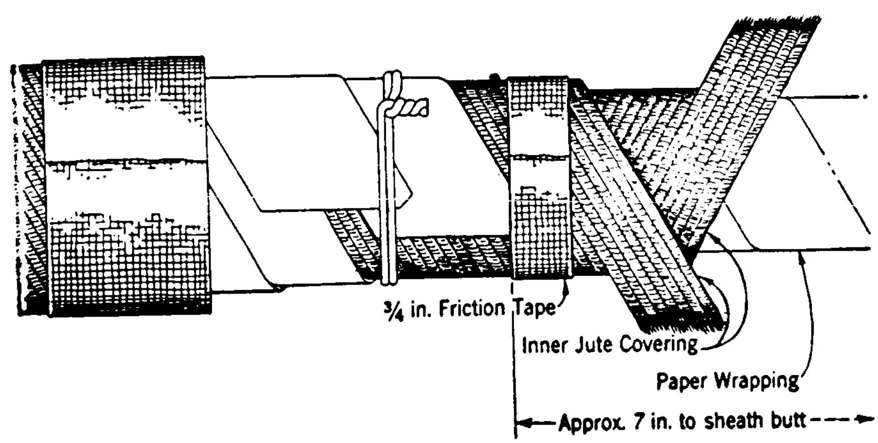
The covering on buried tape-armored cable consists of impregnated paper, a cushion of jute, two steel tapes, and an outer covering of jute.

The method of removing the covering on buried tape-armored cable is outlined below:




2 in. Friction Tape Collar
Inner Steel Tape
Outer Steel Tape
Outer Jute Covering
Approximately 11 in. to sheath butt


Inner Jute Covering
Approximately ½ in.
109 Galvanized Steel Construction Wire


¾ in. Friction Tape
Inner Jute Covering
Paper Wrapping
Approx. 7 in. to sheath butt

a. At the point where the outer serving (covering) of jute is to be terminated, apply four turns of 2-inch friction tape so located that when the splice opening is made, there will be approximately 4 inches of armor and 7 inches of sheath exposed at each end of the opening. Then remove the covering as outlined below.

b. Cut tape longitudinally with metal snips and trim corners as shown. Apply two turns of 109 galvanized steel construction wire or equivalent around tapes.

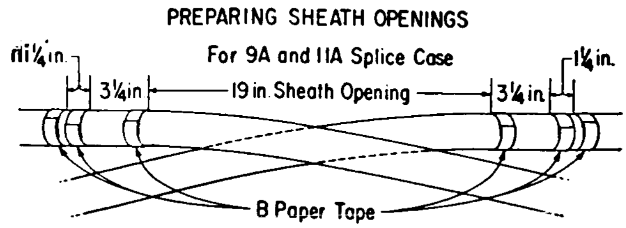
c. Apply four turns of 3/4-inch friction tape covering 1/4 inch of inner steel tape as shown below. Remove jute and paper wrappings to edge of friction tape and clean sheath.

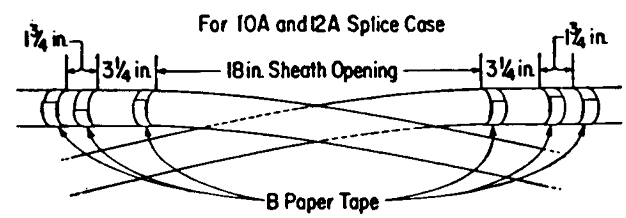
Alpeth sheath consists of a layer of straight or corrugated aluminum and an outer layer of polyethylene. The BHBG cable used in Mercury applications has a polyethylene-aluminum–polyethylene sheath (PAP).

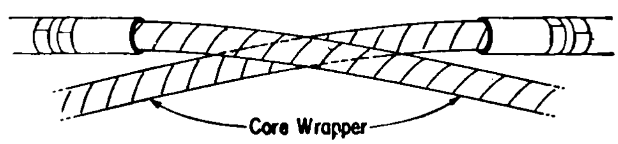
Prior to opening the sheath, as described below (for a 9A, 10A, 11A, or 12A splice case), the cables must be set up and tied firmly in position. The sheaths must be straight and in line for a minimum length of 8 inches from the sheath butt.

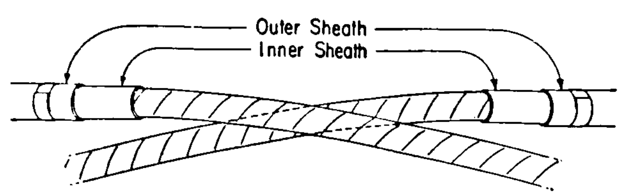
Mark the center of the splice. Then place B paper tape markers on the sheath as illustrated.

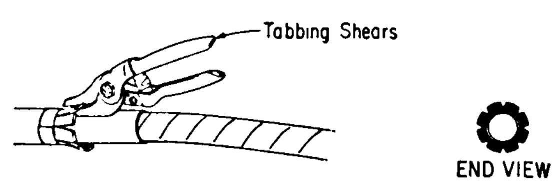
PREPARING SHEATH OPENINGS











Remove sheath between inner tape markers exposing core wrapper. Then remove inner tape markers.

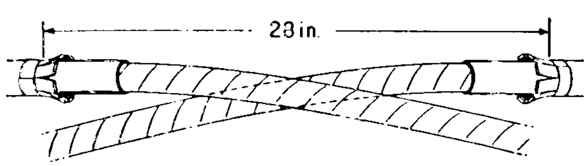
Remove 3-1/4 inches of outer sheath and underlying metal to tape markers as illustrated. Then remove inner tape markers.

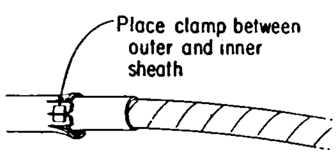
With the tabbing shears make four longitudinal cuts, 90 degrees apart through the outer sheath to the edge of the scotch tape marker. The cuts should be made through the polyethylene and metal layers. Avoid damaging the inner polyethylene sheath.

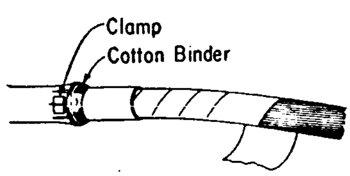
On cables larger than 1.6 inches in diameter, slit each tab in half to make a total of eight tabs.

Make sure that the distance between remaining tape markers is 8 inches. Remove B paper tape markers.

Slip the inner sheath clamp under the tabs as illustrated below.







Starting about 1/2 inch under the tabs make two straight turns of 1-inch cotton tape over the inner sheath. Then bring the cotton tape out through one of the slits between the tabs and bind the tabs down to the inner sheath with two additional turns of cotton tape.

Place temporary bond across splice in the usual manner attached to the ears of the inner clamp. Then check the separation between the ears of the inner sheath clamps. The distance between them should be about 26-1/2 inches.

SHEATH PREPARATION "Y" OR DOUBLE "Y" SPLICE

The preparation of the sheath ends is the same as outlined.

The above procedure varies somewhat where an isolated splice case is to be installed at a buried splice. See paragraph 2.3.2.9, a.

2.3.2.4 *Core Preparation*

BHB, BHA, BKM, and BKT—EVEN PIC *Cables*—These are fully color coded, with pairs arranged in 25-pair binder groups. On opening the cables, each binder group to be worked on must be individually marked to keep the pairs permanently associated. This can be done by using short lengths of paired, polyethylene-insulated conductors of the same color combination as the binder, or by means of colored-plastic rings.

If the binder group consists of two or three units, remove the binding strings from each of these units and combine the pairs of the binder group, using one of the marking methods illustrated.

The insulated wire method can be used at splices or ready-access terminals. It is particularly well adapted for use in the larger cables. Colored plastic rings can be used at ready-access terminals or in small cables.

2.3.2.5 *Conductor Splicing*

a. *EVEN PIC Cables—Color-Code Splicing*

The core makeup, color coding, and pair numbering in BHB, BHA, BKM, and BKT-type cables are covered in Table II, and Figure 1-1.

Subscriber and Trunk Use: In general, EVEN PIC cable pairs are spliced color to color throughout their length, unless otherwise specified in the detail plans. Splices should be made in accordance with the following rules:

TABLE II

EVEN PIC CABLES—COLOR CODE

25 Pair Color Code			*Color Code In Standard Binder Groups*		
Pair Number Sequence	*Color Code Tip*	*Ring*	*25 Pair Unit*	*12-13 Pair Units*	*8-8-9 Pair Units*
1	W	BL			
2	W	O			
3	W	G			
4	W	BR			8 Prs
5	W	S			
6	R	BL		12 Prs	
7	R	O			
8	R	G			
9	R	BR			
10	R	S			
11	BK	BL			
12	BK	O			8 Prs
13	BK	G	25 Prs		
14	BK	BR			
15	BK	S			
16	Y	BL			
17	Y	O			
18	Y	G			
19	Y	BR		13 Prs	
20	Y	S			
21	V	BL			9 Prs
22	V	O			
23	V	G			
24	V	BR			
25	V	S			

ABBREVIATIONS

BL – Blue	W – White
O – Orange	R – Red
G – Green	BK – Black
BR – Brown	Y – Yellow
S – Slate	V – Violet

EVEN PIC to EVEN PIC:

(1) Cables of the Same Size: Splice like-colored binder groups only. Join pairs color to color.

(2) Taper Points and Bridge Points: Splice complete binder groups only. In joining binder groups of unlike color, the normal sequence of binder colors must be maintained. Join the pairs color to color.

(3) Exception: In splicing 6, 11, or 16-pair cables to a binder group, splice color to color at the start of the group, otherwise in color code sequence.

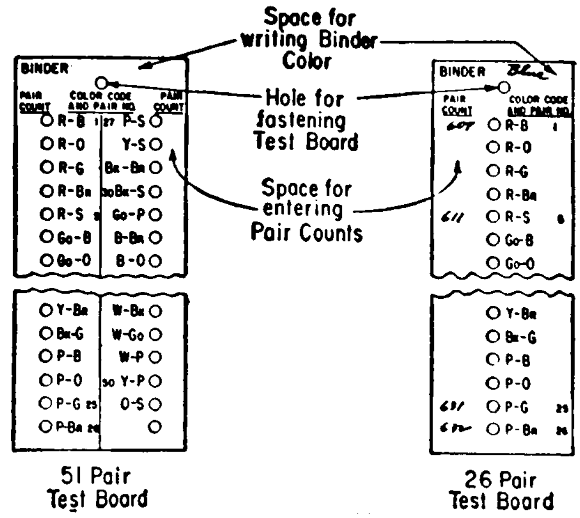
b. *Test Boards*

Test boards are used for tagging pairs as they are identified, preparatory to splicing.

(1) Linen test boards for tagging identified pairs are available in two numbered series for boarding cables up to and including the 2121 pair size. One series consists of 42 boards covering the full-cable count from 1 to 2121, each board having 51 consecutively numbered holes. The other series consists of two boards each having 71 consecutively numbered holes, 1 to 71 and 51 to 21. In these boards, the hundreds digit is added as required. Either type of board may be provided, depending on local practice. The linen boards are generally used at splices, where the work may not be completed in one day and, where the splice may have to be wrapped before the operation is completed.

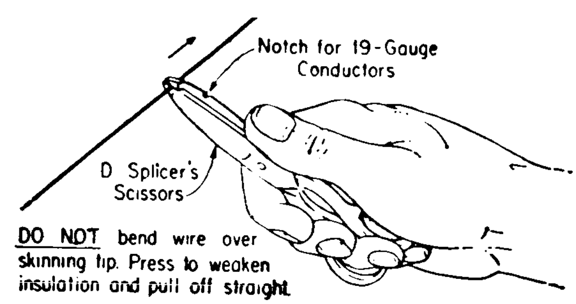
(2) Fibre test boards for tagging identified pairs are available in the same series as the linen boards described in paragraph 2.3.2.5 a. These test boards are too hard and stiff to be wrapped readily in the splice and they are therefore generally used when small complements are being boarded, as in testing distribution terminals, in which the splice will not ordinarily have to be wrapped during the splicing operation.

(3) New-type test boards are provided for convenience in associating pairs when splicing PIC cables or units of dissimilar size, making cable transfers, etc. Two sizes are available, 26 pairs and 51 pairs, as illustrated below. The boards are marked to show pair numbers and colors. Space is provided for writing in the color of unit binding strings and the main frame or cross-connecting terminal pair count when necessary.



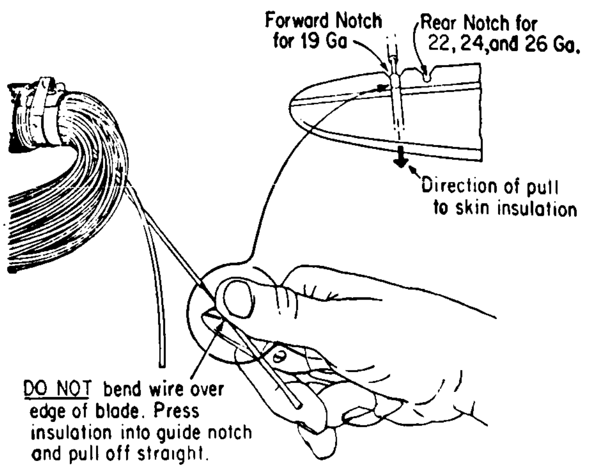
c. *Removing Insulation*

D-type splicer's scissors: The stripping tip is intended primarily for removing insulation from 22-, 24-, and 26-gauge conductors. A notch is provided on one blade for removing insulation from 19-gauge high or low capacitance pairs. The method of using the stripping tip is illustrated below.



Do not bend wire over skinning tip. Press to weaken insulation and pull off straight.

C Splicer's Scissors: These scissors have two skinning notches, the larger for 19-gauge, the smaller for 22-, 24-, and 26-gauge. These scissors are useful in wire trimming operation in which the cutting must be done with the extreme end of the blade. The method of using the blade is illustrated below.



Do not bend wire over edge of blade. Press insulation into guide notch and pull off straight.

d. *Soldering*

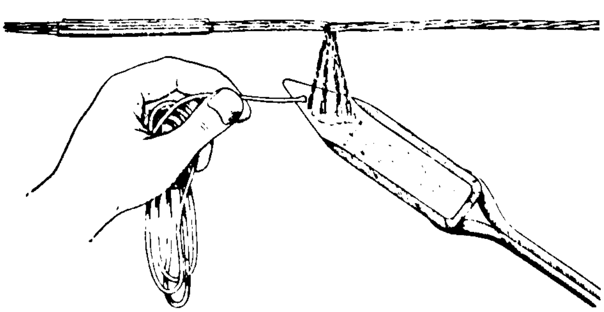
All conductors are twisted and soldered for the following reasons:

(1) To prevent resistance unbalances which would change the electrical characteristics of important circuits.

(2) Large difference in gauge which makes it difficult to obtain a tight twist.

(3) To ensure a satisfactory joint where the twists may develop corrosion films because of exposure to rubber insulation.

The soldering should be done with a clean, well tinned soldering copper. If a large number of joints require soldering it is desirable to use the chisel point soldering copper. The solder should cover at least 1/4 inch of the end of the pigtail. It will generally be practicable to heat several pigtails as a group with the copper as shown below:



Solder should be applied to each pigtail but all of the pigtails in the group should be retained on the copper until the last one has been soldered. Excess solder is removed by raising the pigtails on the copper and allowing them to snap back. If the pigtails are located in the upper portion of the splice a muslin pad or a piece of cardboard should be placed below and behind the pigtails so that particles of solder will not be caught in the spliced conductors.

e. *Sleeving*

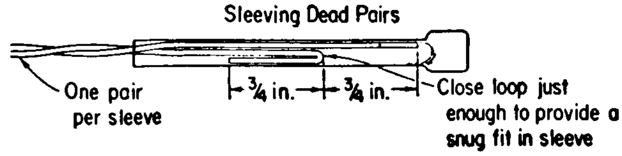
B-type plastic filled sleeves are generally used over the twisted and soldered conductors of a PIC cable.

The sleeve is plastic insulation and is filled with a compound which has sealing properties. These sleeves provide a water-resistant seal on straight, bridge, butt-twisted pigtails, or pressed-sleeve joints and on dead pairs.

Description of Sleeves: The available sizes, color designation and number per package are listed below.

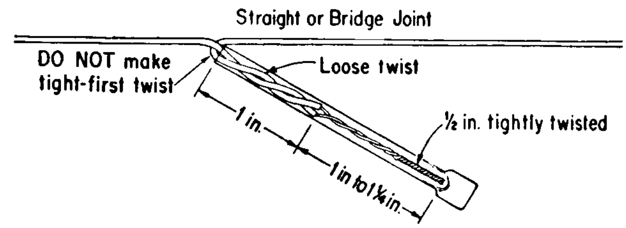
Sleeve Sizes ID–Mils	*Length Inches*	*Color*	*Number per Package*
085	2–1/2	Yellow	525
105	2–1/2	Green	425
125	2–1/2	Natural	325
145	2–1/2	Red	260
165	2–1/2	Blue	200

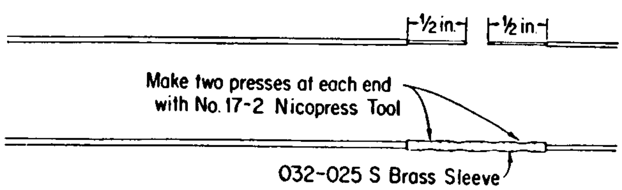
Sleeving Dead Pairs

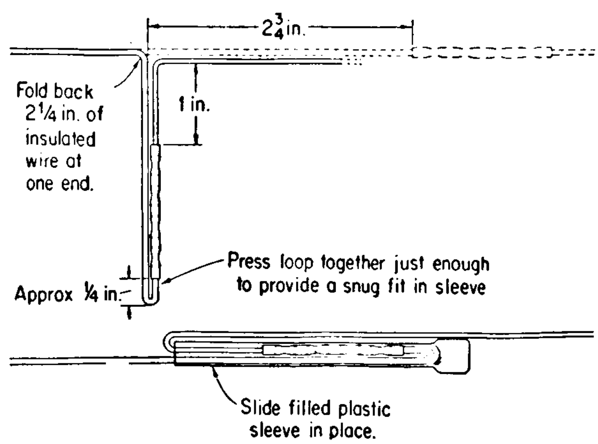


f. *Methods of Making Joints*

Twisted-pigtail joints: The recommended sleeve sizes for twisted-pigtail joints are based on catching at least 1 inch of the insulation in the twist. This is done to ensure complete coverage of the bare conductors and the ends of the insulation by the sealing compound.





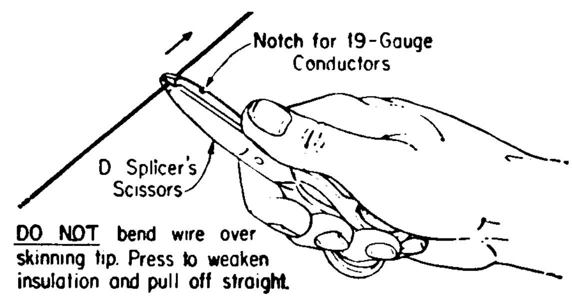


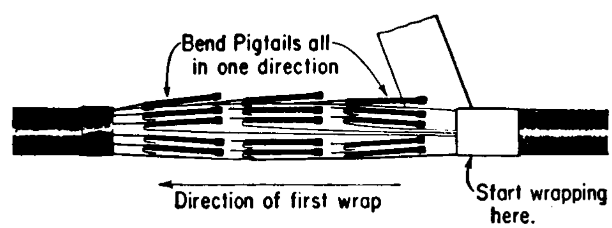
The insulated portion in the pigtail should not be twisted tightly.

In making three-wire joints of equal or nearly equal gauges, the insulated portion in the pigtail must be loosely twisted so as to allow the compound to flow into the space between the wires. Otherwise, the joint may not seal properly.

Pressed sleeve joints are made as illustrated below.

2.3.2.6 *Arrangement of Splice for Wrapping* To avoid the tendency for the sleeves to slip off the joints when wrapping, it is advisable to lay the twisted joints in one direction, as illustrated. On completion of the splice, start wrapping at the end shown and wrap as loosely as practicable.





NOTE

This wrapping procedure applies only to splices in lead sleeves or splice cases.

2.3.2.7 *Splice Covers—(Temporary)*

C- and D-type splice covers may be used for temporary protection of uncompleted splices which require more than one working day to complete and over splices completed in steps where some time elapses between operations at a splice. (See figure 2-5.)

Slide the splice cover over one end of the cable before starting to splice.

The full 5-foot length should be used where space is available at the splice.

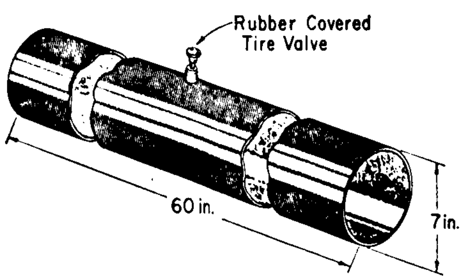
Where space is limited, as in small manholes, or where it is desirable to leave jute or corrosion protection on the cable sheath close to the splice, the length of the splice cover may be shortened by cutting off a portion. However, where the splice will be worked on a number of times before it is completed, the full length of the C-type splice cover is required. In this case, telescope the splice cover to a short length when fastening the ends to the cable sheath.

With the carding brush, clean the sheath where the end of the cover will be clamped. Remove any longitudinal scratches from the cleaned area with a file.

Cover, Splice, C: For use over a straight splice; it is illustrated below.

Cover, Splice, D: For use over a splice having a stub at one end; it is illustrated below.

Cover, Splice, C: For use over a straight splice; it is illustrated below.



Cover, Splice, D: For use over a splice having a stub at one end; it is illustrated below.

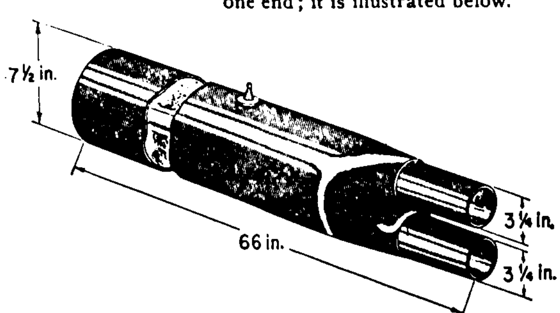


FIGURE 2-5. C AND D SPLICE COVER

Wrap four concentric turns of 2-inch wide DR tape over the cleaned area as shown, to form a cushion for the cover and the clamp. Do not apply C cement to the cleaned area because this makes it difficult to remove the DR tape collars later.

Remove the valve cap and valve core. Slide the C splice cover into position and turn the ends back about 6 inches, as shown. Then paint a 2-inch wide band of C cement on the turned-back ends of the cover and allow the cement to dry for about 5 minutes.

Turn each edge of the collar back so that the cemented portion is aligned over the DR tape collars. Smoothly press the cemented portion of the cover around the circumference of the collar, avoiding wrinkles. Press the excess portion of the cover into one fold, as shown.

Wrap the excess portion of the cover around the part against the collar, and tape in place.

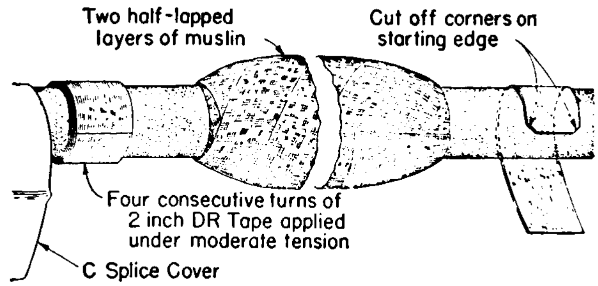
Examine each sealing clamp. The projecting lip fastened to the housing should contact the punched portion of the strap as it enters the housing. Bend the projecting lip towards the punched portion, if necessary, so that the lip will not cut through the friction tape and the splice cover.

Place a sealing clamp over the center of each collar and tighten the clamp until the collar is compressed sufficiently to seal off any passages.

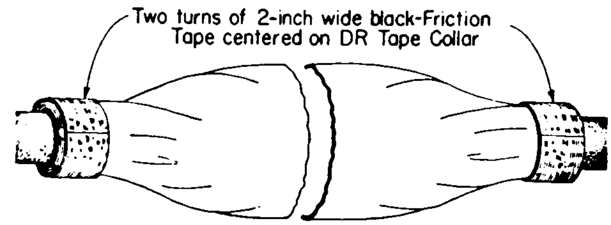
Apply two concentric turns of 2-inch wide black friction tape to the overlapped portion of the ends of the C splice cover inside the collars.

2.3.2.8 *Wrapping Completed Splice*

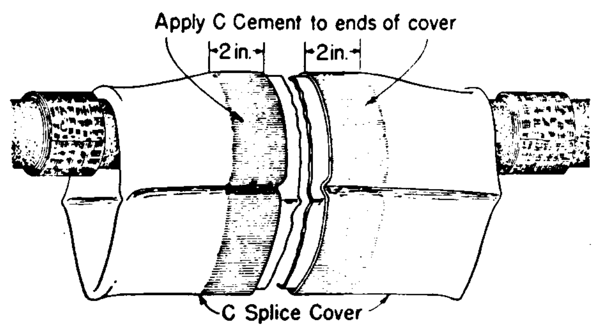
On completion of the wire work at splices to be enclosed in splice cases or lead sleeves, the splice is protected with one half-lapped layer of B-type polyethylene tape, the end turn of which is secured with B-type paper tape, followed by one half-lapped layer of muslin.



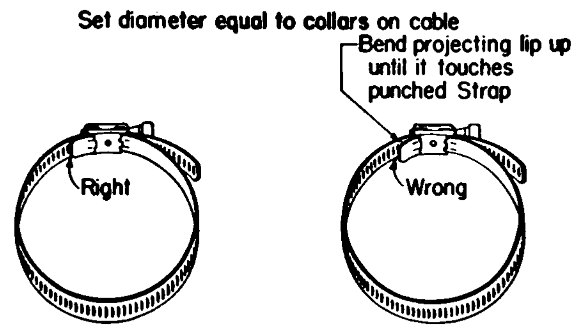
Two half-lapped layers of muslin
Cut off corners on starting edge
Four consecutive turns of 2 inch DR Tape applied under moderate tension
C Splice Cover



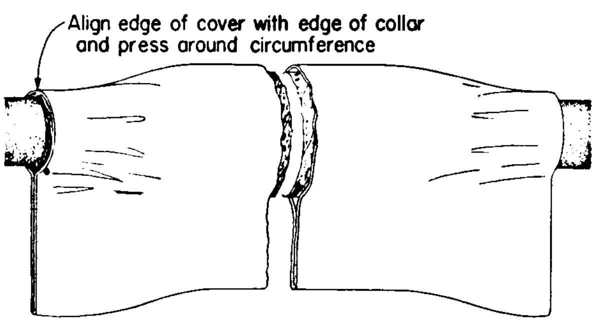
Two turns of 2-inch wide black-Friction Tape centered on DR Tape Collar



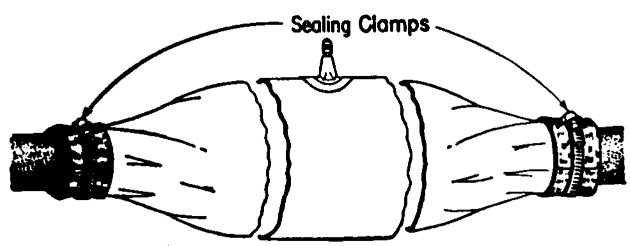
Apply C Cement to ends of cover
2 in.
2 in.
C Splice Cover



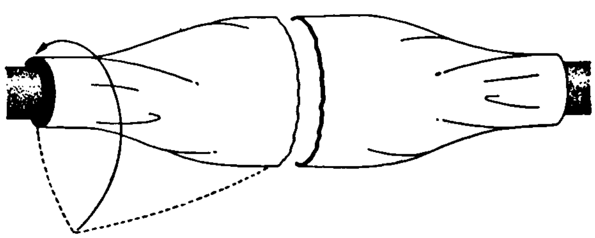
Set diameter equal to collars on cable
Bend projecting lip up until it touches punched Strap
Right
Wrong

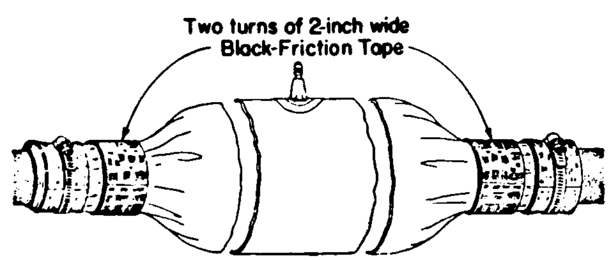


Align edge of cover with edge of collar and press around circumference



Sealing Clamps





Two turns of 2-inch wide Black-Friction Tape

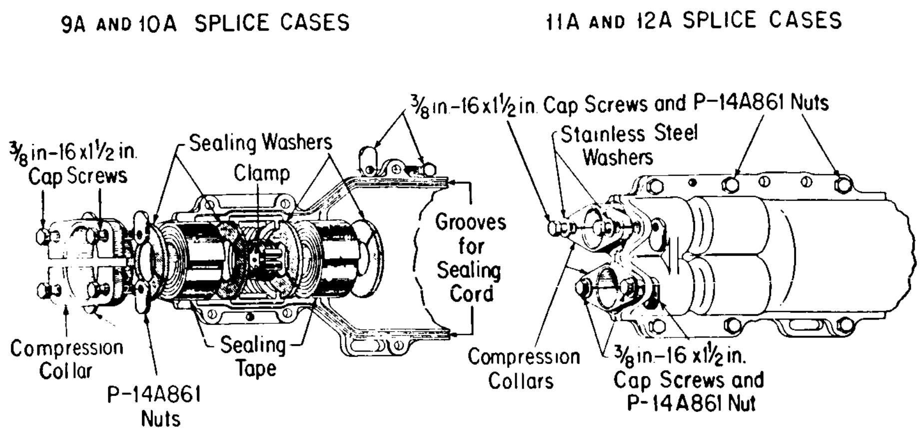
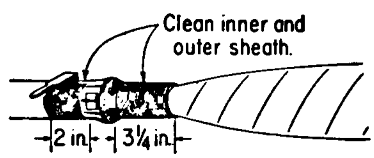


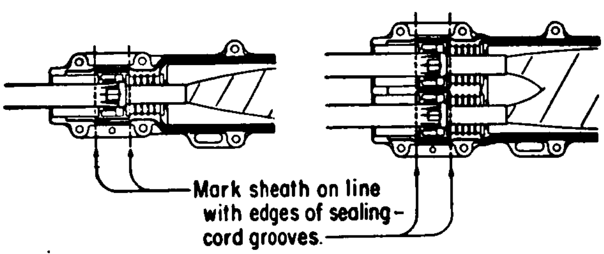
FIGURE 2-6. 9A, 10A, 11A, AND 12A SPLICE CASES

2.3.2.9 *Splice Case Installation*

See Figures 1-6, 2-6 and paragraph 1.4.2.5 for descriptive information concerning splice cases. Clean the sheath as illustrated below.

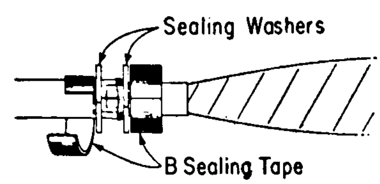


Position the cable in the splice case and mark the sheath as illustrated below.

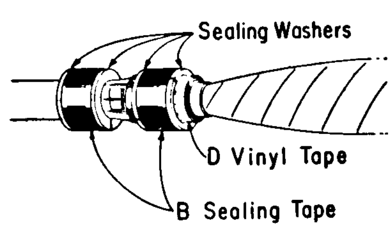


Remove the splice case. Then select the proper size sealing washers from the table in paragraph 1.4.4.3.

Place two washers on the sheath alongside the marks previously made. If combination lead and polyethylene washers are required, they must be placed with the polyethylene facing the B-type sealing tape. Then build up collars of B-type sealing tape on the sheath until the diameters are equal to or slightly larger than that of the sealing washers. Butt all joints between the sealing tape strips. The tape must be kept clean and must not be stretched.



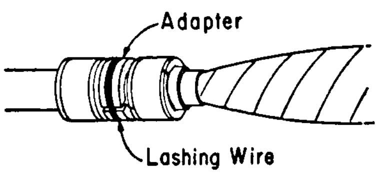
Place two additional sealing washers as illustrated below. The washers at the ends of each seal must be rotated so that the slits are at least 90 degrees apart. Then wrap a collar of D-type vinyl tape about 1/2-inch around the inner sheath closing the opening between the sheath and the sealing washer.



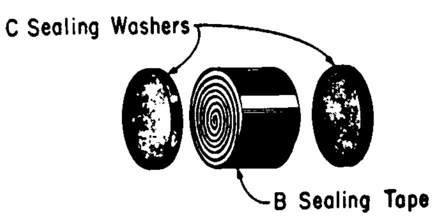
If a small size cable is to be installed, an adapter of the proper size and type must be placed on the cable to provide contact with the case for bonding as outlined below.

a. Place spacers around inner clamp.

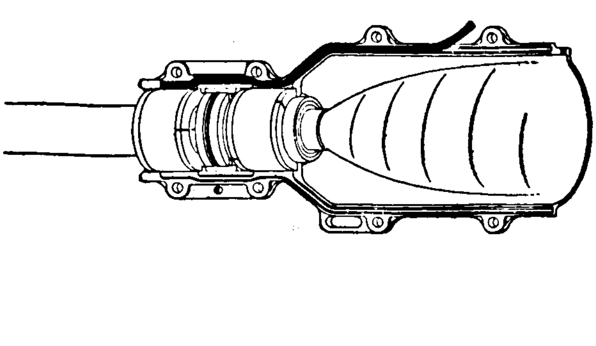
b. Bind down securely with several turns of lashing wire placed in the grooves provided in the spacers for that purpose.



Any unused cavity in the splice case can be filled with a plug of B-type sealing tape. A solid C or D-type sealing washer of the proper diameter must be placed at each end of the plug.



Place the cables in the splice case. Then clean any dirt or filings from the sealing cord grooves in the splice case with a brush or dry cloth. Place sealing cord in the side grooves being careful to avoid making flat spots or dents in the cord. Do not stretch. It may be necessary to push the B-type sealing tape away from the grooves at the ends in order to permit placing the sealing cord.



Place other splice case in position being careful not to disturb the B-type sealing cord.

Start bolts and nuts in castings, beginning at the center and working towards the end of the castings. Using the B-type wrench kit, tighten uniformly until the separation between the castings is slightly less than 1/8-inch.

Place end collars in position and insert screws until they completely engage the nuts. Then tighten the bolts on the sides of the cases until metal to metal contact is obtained. The arrangement of the two types of end collars is illustrated in Figure 2-6.

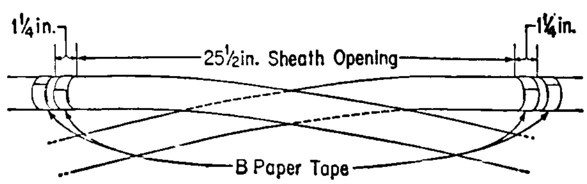
Tighten bolts on end collars uniformly. The presence of compound oozing out of the castings indicates that they are sufficiently tight. Then place ground lug and secure bonding ribbon.

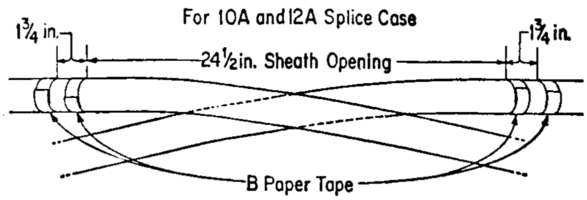
2.3.2.10 *Isolation of Aluminum Shield and Splice Case.*

The following method must be followed in installing splice cases that are buried.

If the cable has mechanical protection in the form of tape or wire armor, it must be made continuous across the splice opening as outlined in paragraph 2.3.2.12. Remove only enough of the mechanical protection so that when the splice-case installation is completed, the tape or armor must extend to within 1/2 inch of the case at each end.

Place paper tape markers on sheath as illustrated below.

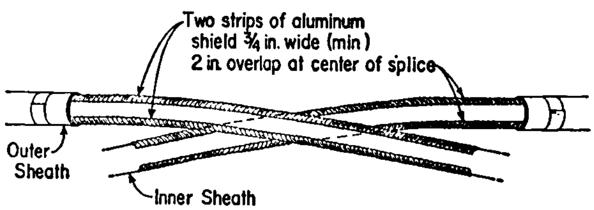




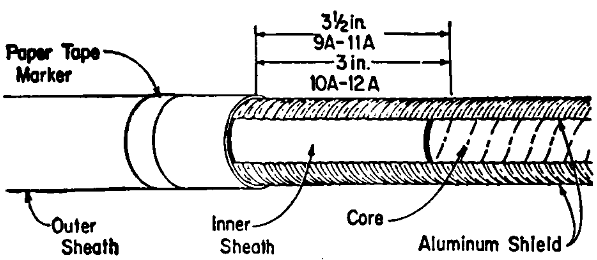
NOTE

At openings in straight cable such as load points, it is desirable to make the original sheath opening approximately 1 inch shorter to allow for creeping of the sheath.

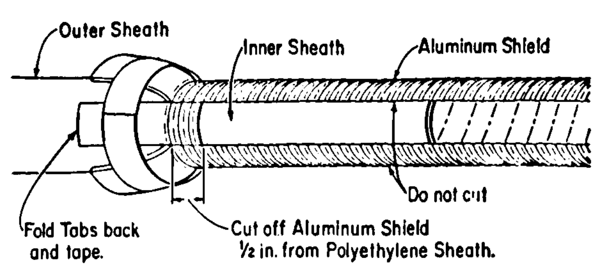
Remove outer polyethylene sheath between inner paper tape markers. Do not disturb underlying aluminum. Then cut two strips of aluminum shield separated by at least 45 degrees as illustrated below. Remove remainder of aluminum shield.



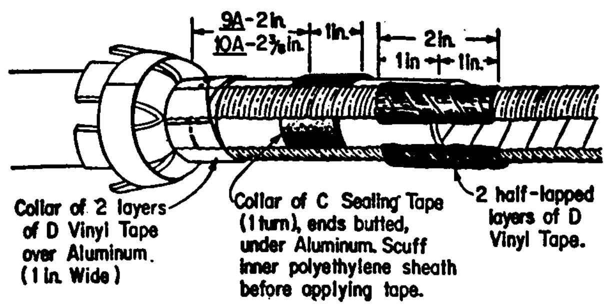
Remove inner sheath as illustrated below.



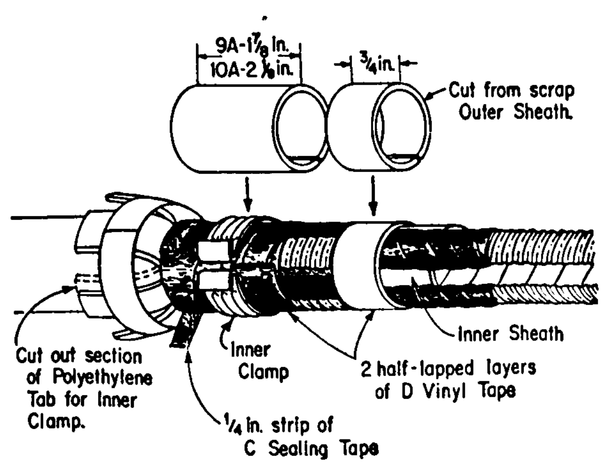
Cut six or eight sheath tabs depending on the cable size. Cut off aluminum shield, except for the two 3/4-inch strips, 1/2-inch from polyethylene tabs as illustrated and trim any rough edges.



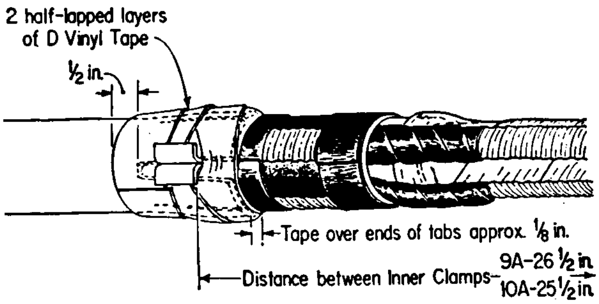
Measurements shown in the following sketch must be accurate and made from paper tape marker on outer sheath. Apply a 1-inch collar of C-type sealing tape as illustrated. Do not stretch C-type sealing tape. Bend the 3/4-inch aluminum strips away from inner sheath only enough to place the collar of C-type sealing tape. Then form the aluminum strips over the sealing tape. The D-type vinyl tape collar under the ends of outer sheath tabs must extend 1/2-inch beyond cutoff aluminum tabs. Protect the aluminum strips at the end of the inner sheath with two half-lapped layers of D-type vinyl tape.



Cut two polyethylene collars from scrap outer sheath and place on each side of the C-type sealing tape collar, as illustrated below. D-type vinyl tape must then be wrapped over the full length of each polyethylene collar but must not extend on the C-type sealing tape. The inner clamp must then be placed over the D-type vinyl tape and a 1/4-inch collar of C-type sealing tape placed alongside the folded back polyethylene tabs as illustrated.

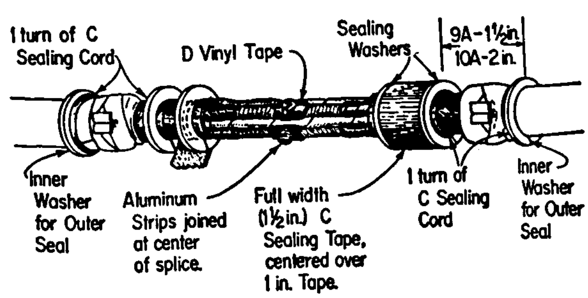


Fold the outer sheath tabs over the inner clamp, forcing the clamp as far under the tabs as possible. Place two half-lapped layers of D-type vinyl tape over the tabs as illustrated. The distance between inner clamps should be 26-1/2 inches in the 9A splice case and 25-1/2 inches in the 10A splice case.



2.3.2.11 *Installing Splice Case*

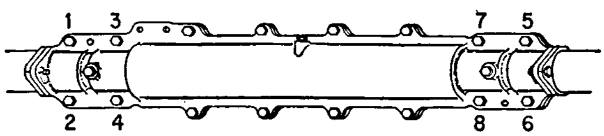
Position splice case to locate inner seal. If 1-1/2 inch-wide strip of C-type sealing tape is centered on 1-inch strip of sealing tape previously placed, the washers should fall in correct position. Slits in sealing washers must close tightly without pinching taped polyethylene collar and D-type vinyl tape covering aluminum strips. It is necessary to use sealing washers at least as large as are required for the outer seal. If the washers are not a snug fit, build a narrow collar of D-type vinyl tape on outside of each washer to prevent free flow of sealing tape when case is assembled. The collars of C-type sealing cord must be pressed into position.



Complete the splice case installation as outlined in paragraph 2.3.2.9. Use only C-type sealing cord for the side seals. Place and tighten bolts.

Place bolts in all lug positions to obtain proper alignment of the splice cases.

Tighten the eight end bolts in the sequence shown below. Then tighten the eight bolts in the center hand-tight.



Continue to tighten eight end bolts two turns at a time in sequence, until clearance between castings is approximately 1/8 inch. Keep center bolts hand-tight.

Starting with the eight end bolts, tighten all 16 bolts one turn at a time. Metal to metal contact is desirable. However, if a lug or pair of lugs are noticeably bent, a gap of 1/32 inch is permissible.

Tighten bolts on end collars uniformly. The presence of compound oozing out of the castings indicates that they are sufficiently tight.

2.3.2.12 *Bonding Tape Armor Across Splice Base*

A 6-type ground wire is used to preserve the continuity of the tape armor protective covering, when a splice case breaks this continuity.

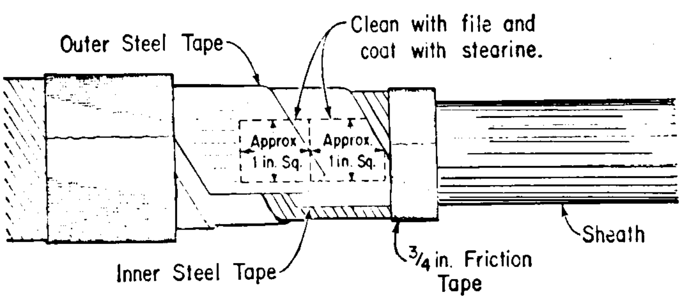
In soldering the 6-type ground wire to the tape or armor covering, extreme care must be taken to ensure that the sheath and the core insulation are not damaged by excessive heating. Use only a well-heated soldering copper. A torch must not be used for this operation.

Before installing the bond, make sure that the tape or wire armor is terminated within approximately 1/2 inch of the splice case at each end with the ends of the wire or armor securely anchored with friction tape. The method is described in paragraph 2.3.2.3 a.

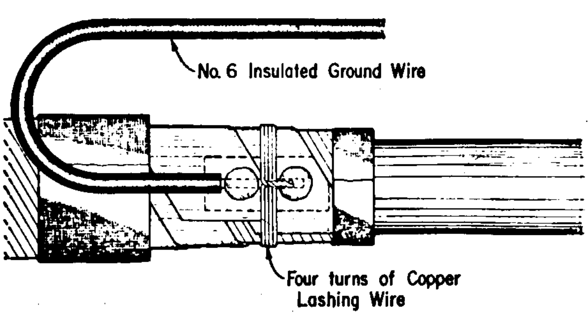
The tinning operations outlined in the following paragraphs can be performed much more quickly and easily by using a small quantity of soldering paste in conjunction with the rosin-core solder. Any excess paste must be wiped off after the tinning is completed.

If corrosion protection is used on the splice case, it must be applied before the bond is placed.

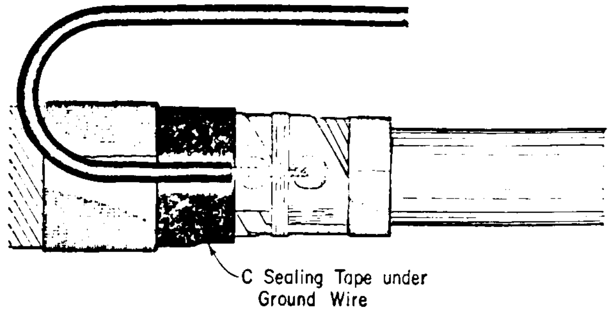
On regular buried, tape-armored cable, clean the steel tapes thoroughly with a file and coat with stearine as illustrated below. Then tin the cleaned areas with rosin-core solder.



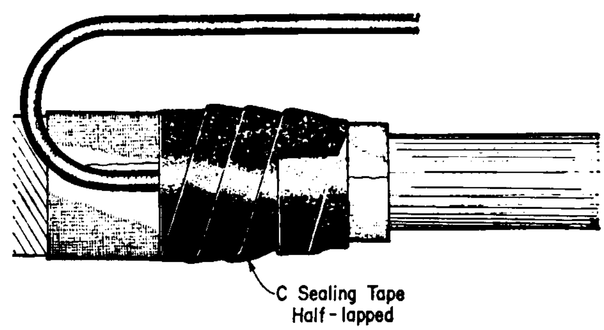
Clean and tin the end of a length of 6-type insulated ground wire. The wire must be sufficiently long so that when it is placed in the trench, it will lie approximately 1 foot away from the body of the splice case. Position the ground wire over the tinned portion of the steel tapes with four turns of copper lashing wire as illustrated below. Then solder the ground wire to the steel tapes with rosin-core solder.



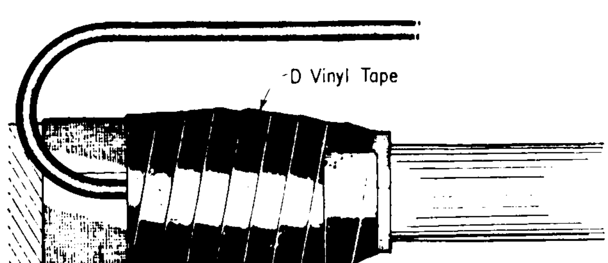
Place one turn of C-type sealing tape under the insulated wire, adjacent to the soldered joint as illustrated below.



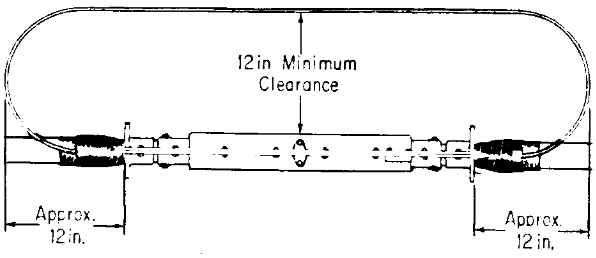
Wrap with one half-lapped layer of C-type sealing tape as illustrated below. Butt the ends of the tape. Do not stretch.



Cover sealing tape and exposed tape armor with two half-lapped layers of D-type vinyl tape extending about 1/2 inch over friction tape at each end.



A completed installation is illustrated below.



2.3.2.13 *Pressure Testing Splice Cases*

Flash testing of the completed splice case is the method used to determine the effectiveness of the seals of the splice case.

The tools supplied for the flash testing are:

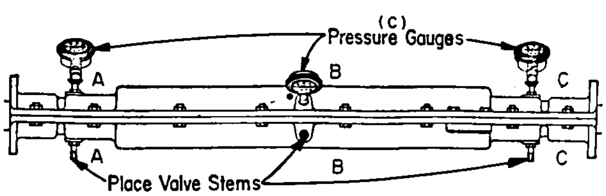
a. C-type pressure gauge

b. C-type pressure testing valve e/w valve cap (R)

c. B-type pressure hose (30 feet)

d. C-type regulator wrench

Place gauges and valve stems on the cases as indicated below.



Test the side seals between the inner and outer seals at each end, and the two outer seals, by admitting air under pressure in valves A and C until gauges A and C read 5 pounds. Use B or C-type pressure-testing solution for test. A small leak in the outer seal can sometimes be closed by removing the end collars, placing an additional lead washer in the end seal, replacing and retightening additional lead washer in the end seal, and replacing and retightening the end collars. Then vent A and C until gauges A and C read zero.

Put air on valve B until gauge B reads 5 pounds. Then test the side seals between the two inner seals with B or C-type pressure testing solution. If no pressure is indicated on gauges A and C after the side seals have been tested, the two inner seals are satisfactory.

Bolts may loosen because of the presence of sealing compound at the bolt locations. Relaxation of this compound will occur during the testing interval. The final operation before covering the splice must be to recheck and tighten all nuts and bolts.

2.3.2.14 *Buried Splice Corrosion Protection*

All buried splice cases must be protected against corrosion. The splice cases must be painted with pressure-plug asphalt, which is supplied in 25 pound cans. The painted splice cases should then be loosely wrapped with muslin before being buried. The muslin may be obtained in 2-inch, 4-inch, and 36-inch widths.

2.3.3 Splicing Synchro Cable

The type 1 and type 2 synchro cables are described in paragraph 1.2.2 and shown in Figure 1-2. The triad and pair splicing procedure and sheath preparation will be the same for both types of synchro cable.

2.3.3.1 *Splicing Materials*

a. Adhesive-backed vinyl tape

b. Lengths of copper shielding braids

c. 3-1/2 inch lengths of polyethylene tubing or sleeving

d. No. 10 AWG tinned-copper sleeves

e. No. 14 AWG tinned-copper sleeves

f. Adhesive-backed aluminum tape

g. Copper lashing wire

2.3.3.2 *Sheath Preparation*

The outer cable jacket must be removed carefully so that there will be no damage to the copper shield.

Unwind the copper shielding tape back to the outer jacket. Position the shield so as not to interfere with subsequent operations.

Remove inner jacket to within 1 inch of folded back-shielding taper.

Remove the mylar tape.

Position the triads and pairs to be spliced.

2.3.3.3 *Conductor Splicing*

Each triad or pair should be spliced as follows:

a. Remove the jacket, being careful not to damage the underlying core.

b. Place a length of copper shielding braid over the jacket on only one side of the splice.

c. Cut off the shielding braid about 3/4 inch from the end of the jacket.

d. Remove the mylar tape on the triad.

e. Place a 3-1/2 inch long polyethylene sleeve over each conductor on only one side of the splice.

f. Strip the nylon and polyethylene insulation, exposing 1 inch of the conductor.

g. Insert the conductors in the tinned copper sleeves. Size No. 10 AWG for the pairs, and size No. 14 for the triads.

h. Solder with rosin-core solder. Avoid excessive heat which may damage the polyethylene. Remove any burrs from the soldered joints.

i. After the joints cool, slide the polyethylene sleeves over the conductors. Tape one end with adhesive-backed vinyl tape to keep it in place.

j. Apply a layer of adhesive-backed vinyl, half-lapped over the pair or triads up to the shielding braid.

k. Center the length of copper shielding braid over the splice, secured at each cable shield with two turns of copper lashing wire, and soldered to the copper shield.

l. Scuff the pair or triad jacket. Apply three layers of adhesive-backed vinyl tape half lapped over the copper-shielding braid and feathered out at 1/2-inch intervals over the jacket.

2.3.3.4 *Sheath Closure*

The sheath should be closed as follows:

a. Stagger the spliced triads and pairs. Scuff the inner and outer jackets.

b. After all the triads and pairs are spliced, apply three layers of adhesive-backed vinyl tape feathered out at 1/2-inch intervals over the inner jacket.

c. Rewrap the copper shielding tapes and solder. If the shields do not meet, solder an additional piece of copper shield. Apply four layers of adhesive-backed vinyl tape, half-lapped over the splice and feathered out over the outer jacket. Apply two layers of adhesive-backed aluminum tape over the splice, half-lapped and feathered out beyond the tapes of preceding step. Iron into a smooth, tight, moisture-proof fit by using the shank of a screw driver or handle of a cording tool.

d. Apply two layers of adhesive-backed vinyl tape, half-lapped and feathered out beyond the adhesive-backed aluminum tape.

2.3.4 Splicing Plotboard (Radar Display) Cable

The special six-conductor plotboard cable is described in paragraph 1.2.3 of this section.

2.3.4.1 *Splicing Materials*

a. No. 14 AWG tinned-copper sleeves

b. Adhesive-backed polyethylene tape

c. Adhesive-backed vinyl tape

d. 22 AWG tinned-copper binder wire

e. Adhesive-backed aluminum tape

2.3.4.2 *Sheath Preparation*

The outer cable jacket must be removed carefully so that there will be no damage to the copper shield. Unwind the copper shielding tape back to the jacket. Position the shield so as not to interfere with subsequent operations.

Remove the core tape.

2.3.4.3 *Conductor Splicing*

Each shielded conductor should be spliced as follows:

a. Push back the shielding braid exposing the conductor insulation. Strip the polyethylene insulation exposing 1 inch of the conductor. Insert the conductors in the tinned-copper sleeve. Solder with rosin-core solder. Avoid excessive heat which may damage the polyethylene. Remove any burrs from the soldered joints.

b. After the joint cools, apply four layers of adhesive-backed polyethylene tape, half-lapped over the joint and feathered out over the polyethylene insulation.

c. Pull the shielding braids over the splice, overlapping one shield with the other. Apply two turns of binding wire (22 AWG tinned copper) and solder the shields at the overlap.

2.3.4.4 *Sheath Closure*

The sheath should be closed as follows:

a. Stagger the spliced conductors. Scuff the jacket using No. 2-1/2 grade sand paper.

b. After all the conductors are spliced, apply two layers of adhesive-backed vinyl tape, half-lapped over the splice. Rewrap the copper shielding tapes and solder. If the shields do not meet, solder an additional piece of copper shield. Apply four layers of adhesive-backed polyethylene tape, half-lapped over the splice and feathered out over the cable sheath at 1/2 inch intervals. Apply two layers of adhesive-backed aluminum tape over the splice, half-lapped and feathered out beyond the polyethylene. Iron into a smooth, tight, moisture-proof fit by using the shank of a screw driver or handle of a carding tool.

c. Apply two layers of adhesive-backed polyethylene tape, half lapped and feathered out beyond the adhesive-backed aluminum tape.

2.4 TERMINATING CABLES

2.4.1 Buried Cable Termination

The communications cables are terminated on verticals of the combined distribution frame-(CDF) in the T&C, FPS-16, and receiver buildings at the various sites.

The verticals are equipped with C-50A and C-52A protected terminals.

At these locations, the synchro and plotboard cables are terminated on verticals equipped with 196- or 198-type terminal strips.

At the hardstand location of the verlort and A/G transmitter vans, the communications cables are terminated on 1A4A terminals in a special weatherproof box which measures 36 inches x 48 inches x 10 inches. These boxes house two 51-pair 1A4A terminals or any combination of two 51-, 26-, or 10-pair terminals. Plastic duct seal is used to weather seal the lead sub of the 1A4A terminal where it passes through the opening in the box.

CAUTION

Under no circumstances should this duct seal contact any of the polyethylene sheath.

The synchro and plotboard cables also terminate in these special boxes, mounted at the hardstand locations. These cables are terminated with multiconductor jacks which are locked in openings in the bottom and sides of the box. Jumper cords equipped with plugs are used for conductor cross connection between the multiconductor jack terminations. Where bridged connections are required, a Pacific automation terminal strip is used for cross connection purposes.

In the generator buildings of the various sites, the communications cables are terminated in 10-, 26-, or 51-pair 1A4A terminals. The 1A4A terminal is mounted in 1A1 and 2A1 cable terminal sections. The 1A4A terminals and 1A1—2A1 terminal sections are described in paragraphs 1.4.2.1 and 1.4.2.2 and are shown in Figure 1-4.

2.4.2 Color Code (Terminal Stubs)

The D-type, inside wiring, cable color code, used in the lead terminal stub is:

Pr	*Colors*	*Pr*	*Colors*
1	White–Blue	18	Yellow–Green
2	White–Orange	19	Yellow–Brown
3	White–Green	20	Yellow–Slate
4	White–Brown	21	Violet–Blue
5	White–Slate	22	Violet–Orange
6	Red–Blue	23	Violet–Green
7	Red–Orange	24	Violet–Brown
8	Red–Green	25	Violet–Slate
9	Red–Brown		(A novelty or tracer
10	Red–Slate		is used and the colors
11	Black–Blue		repeated to extend
12	Black–Orange		the count.)
13	Black–Green	26	White–Bl/Wh
14	Black–Brown	27	White–Or/Wh
15	Black–Slate	28	White–Gr/Wh
16	Yellow–Blue	29	White–Br/Wh
17	Yellow–Orange	30	White–Sl/Wh

The last pair (51, 101, etc.), is always red-white. When the D-type, inside wiring cable is changed to the new PIC, even count, cable system, the red-white tracer pairs in the 1A4A-26 and 51-type terminal blocks must be eliminated. The red-white tracer pairs in the 1A4A-10 and 16-type terminal blocks must change to the normal PIC, even count, cable color code for these pairs.

2.4.3 Multiple Drop Terminations

2.4.3.1 *104B Wire Terminals*

The aerial, multiple drop wire at Town Hill, Bermuda, between the telemetry building and the generator building, is terminated in 104B wire terminals at both ends.

The 104B wire terminal is described in paragraph 1.4.2.3 and is illustrated in Figure 1-5.

2.4.3.2 *Multiple Drop Wire—Removing Jacket*

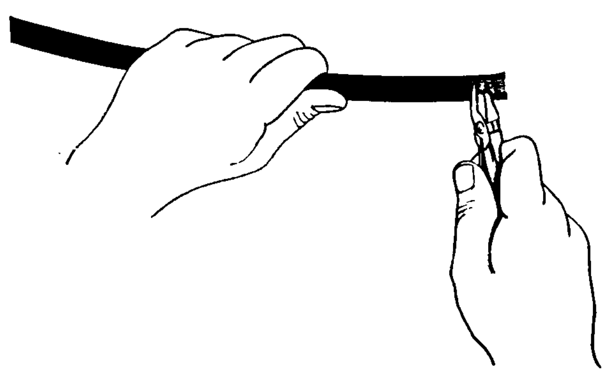
Use 6-inch SW diagonal pliers for cutting across multiple-drop wire. It is necessary to make several cuts with the pliers to complete the operation. Make an initial cut in the wire with the points of the pliers and bend the wire back at the cut so as to expose the inside conductors. Then proceed to cut a few conductors at a time until the cut is completed.

Eight-inch, side-cutting pliers can also be used for cutting multiple wire. It may require several presses of the pliers to cut through the wire.

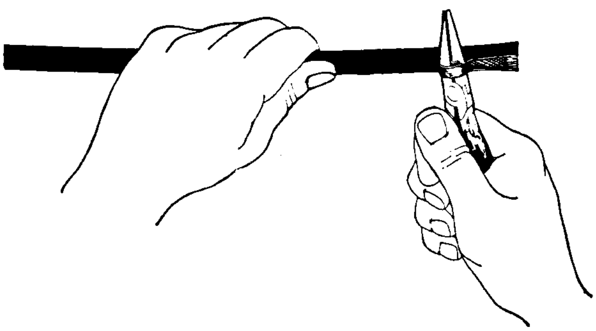
In terminating multiple drop wire at terminals and protectors, it is necessary to remove the outer jacket in order that the pairs can be fanned out. Strip the jacket as follows:

a. Make two longitudinal cuts opposite each other on the multiple drop wire by means of the large groove of the C-type braid stripper.

b. Grip the jacket at the wire end with diagonal pliers and roll the jacket back on itself as illustrated:



c. Release the rolled-back portion of jacket and grip it again with long nose pliers. Again, roll the jacket back on itself until it pulls free of the glass yarn tape, then pull off the jacket with a strong steady pull over the required distance from the wire end.



d. Repeat operations of subparagraphs b. and c. for the remaining segment of jacket.

e. Unwrap the glass yarn tape around the wire core and fan out the pairs for conductor skinning and terminating. Cut off excess yarn tape and filler.

2.4.3.3 *Color Code—(Multiple Drop Wire)*

Pair	*Tip*	*Ring*
1	White	Blue
2	White	Orange
3	White	Green
4	White	Brown
5	White	Slate
6	Red	Blue

SECTION 3. INTRASITE CABLE LAYOUTS

3.1 GENERAL INFORMATION (Schematic Diagrams)

3.1.1 Bermuda (See Figure 3-1.)

The cable installation at Bermuda consists of buried communications cable, type-1 and type-2 synchro cable, plotboard cable, and multiple drop wire. From the main cable run to the telemetry and control building at Coopers Island, an underground installation with manholes and conduit, is employed. At Town Hill, a buried communications cable 1900 feet in length is spliced to the existing main cable route. This makes pairs available to the Town Hill telemetry-receiving installation. Multiple drop is employed between this point and the generator building.

3.1.2 Grand Canary (See Figure 3-2.)

The cable installation at Grand Canary consists of a buried communications cable, type-1 and type-2 synchro cable.

3.1.3 Kano and Zanzibar (See Figures 3-3 and 3-4.)

The Mercury cable installation at Kano and Zanzibar consists of buried communications cable between all buildings and a type-2 synchro cable between the T & C building and the A/G transmitter-van hardstand.

3.1.4 Muchea and Woomera (See Figures 3-5 and 3-6.)

The cable installation at the Australian sites (Muchea and Woomera) consists of buried communications cable, type-2 synchro cable, and plotboard cable (Muchea only). The communications cable, equivalent to Western Electric Company's BHBG-BT cable, is supplied by the Post Master General, Department of Supply, Australia. The type-2 synchro cable is supplied by Western Electric Company and the plotboard and special Bendix cables are supplied by Bendix Radio.

3.1.5 Canton Island (See Figure 3-7.)

The additional cable installed on Canton Island for the Mercury operation includes buried and underground communications cable from the Federal Aviation Agency's (FAA) Private Automatic Exchange (PAX), control building, and terminal building to the Mercury site. Buried communications cables and a type-2 synchro cable are installed in the Mercury area.

3.1.6 Guaymas (See Figure 3-8.)

The Guaymas, Mexico, cable installation consists of buried communications cable type-1 and type-2 synchro cable and a radar-display (plotboard) cable.

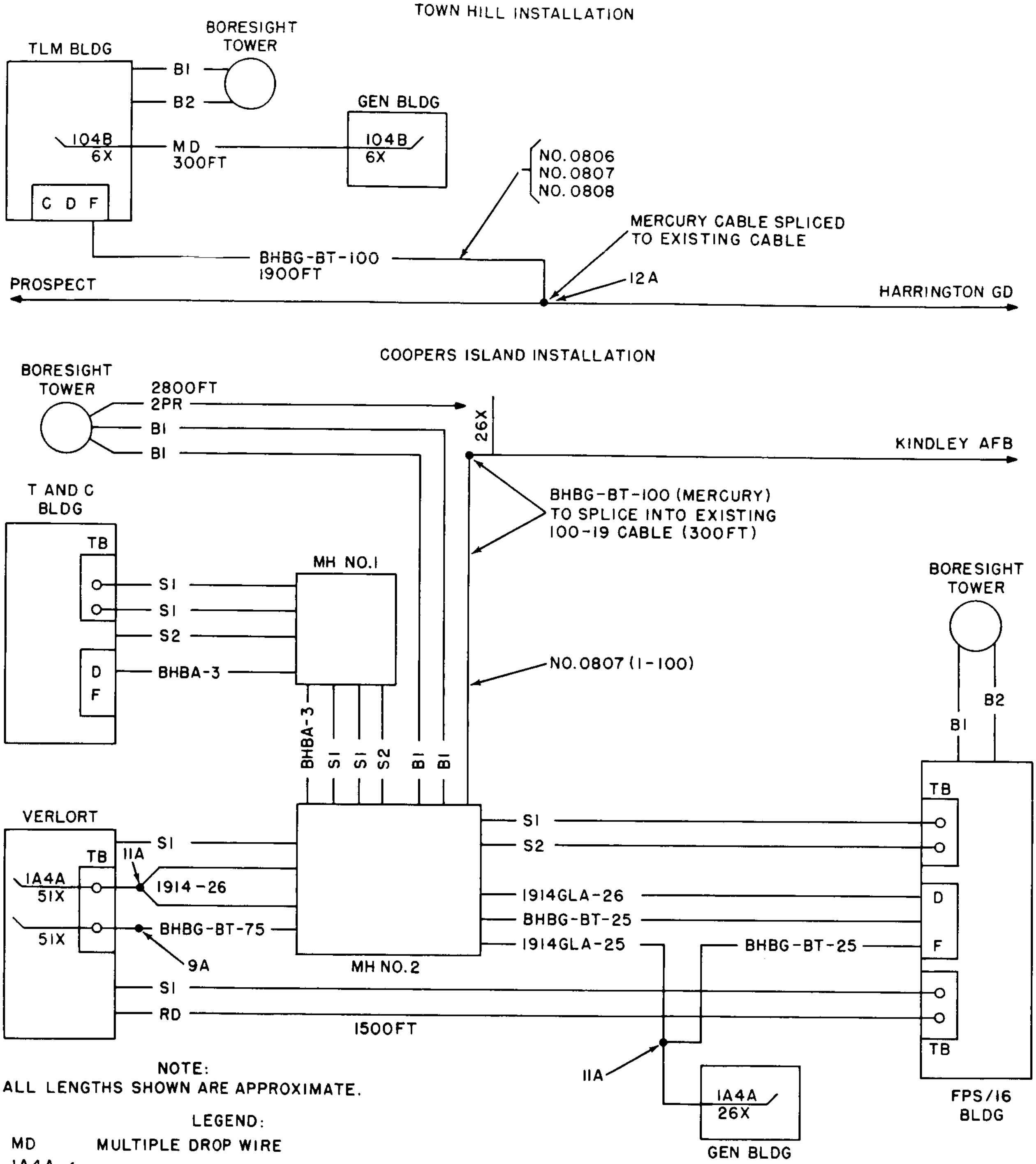
3.1.7 Other Sites

The cables required for Mercury operation at Cape Canaveral are supplied by the organizations presently operating at these locations.

At Kano, an additional communications cable is installed between the receiver and transmitter (hf point-to-point) locations. This cable is provided and maintained by the post and telegraph department at Nigeria.

3.1.7.1 *Hawaii* (See Figure 3-9.)

The outside plant facilities consist of communications, synchro, plotboard (radar display), and boresight cables. The cables are placed in a duct and manhole underground system. This cable plant at Kauai Island, Hawaii, was installed and will be maintained by the Hawaiian Telephone Co and is included here as reference information (Figure 3-8).

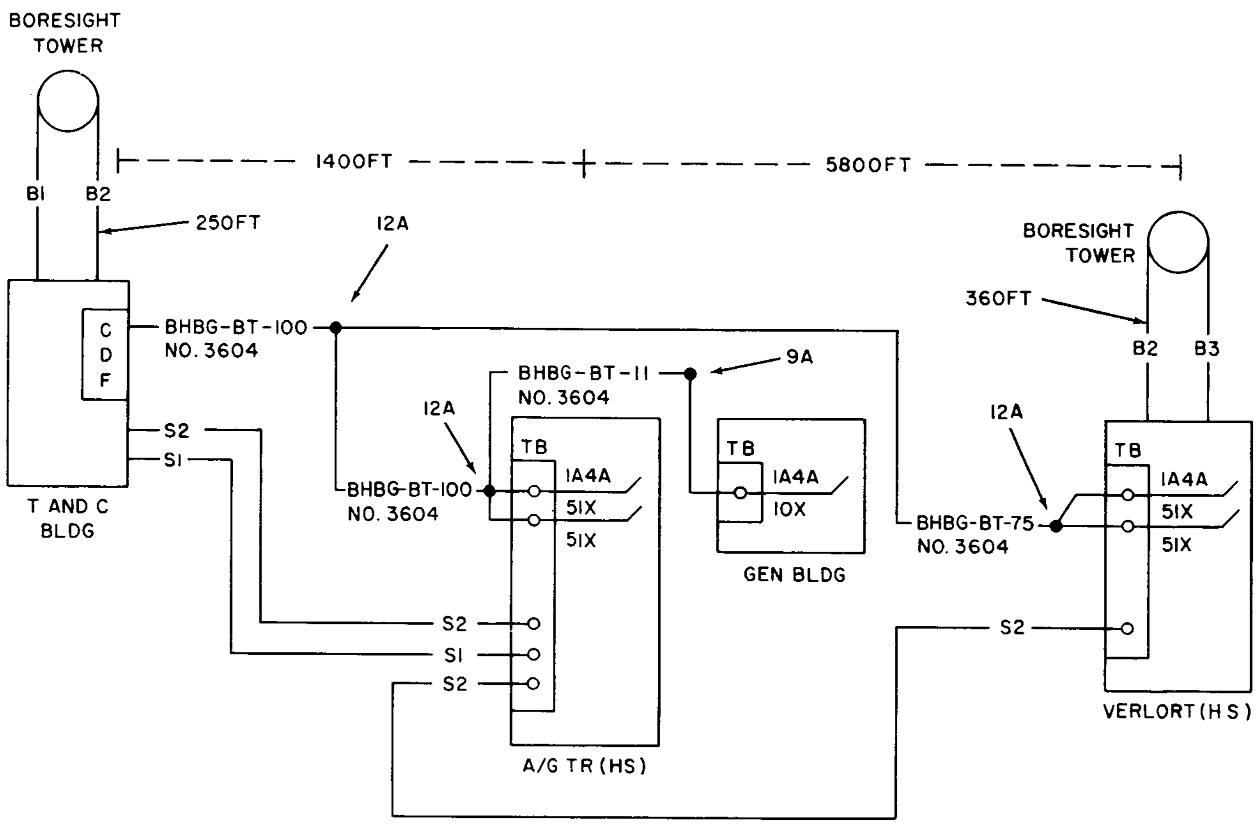


NOTE:
ALL LENGTHS SHOWN ARE APPROXIMATE.

LEGEND:

MD	MULTIPLE DROP WIRE
1A4A / 51X	1A4A TERMINAL - 51 PAIR
11A	SPLICE CASE
RD	RADAR DISPLAY (PLOTBOARD) CABLE
BHBG	COMM CABLE
S1 S2	SYNCHRO TYPE 1 TYPE 2
B1 B2	BENDIX CABLE TYPE 1 TYPE 2 TYPE 3 *
TB	BENDIX TERMINAL BOX
*	SUPPLIED AND INSTALLED BY BX R-(NOT COVERED IN THIS MANUAL)

FIGURE 3-1. OUTSIDE PLANT CABLE SCHEMATIC, BERMUDA

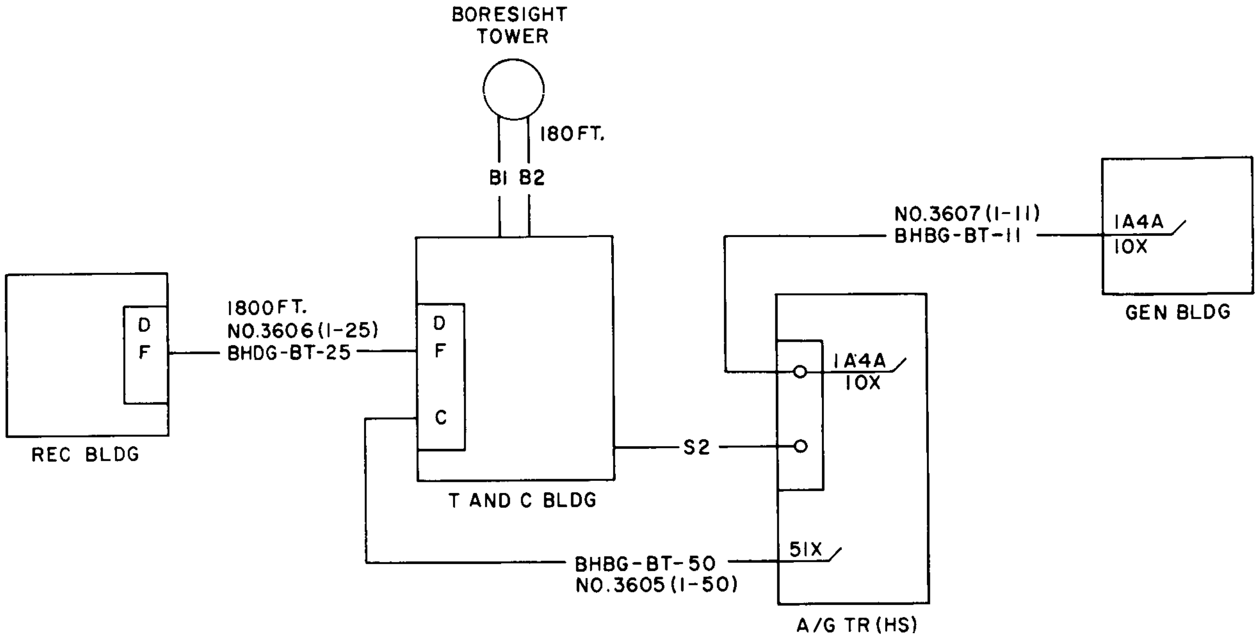


NOTE:
ALL LENGTHS SHOWN ARE APPROXIMATE.

LEGEND

1A4A / 51X	51 PR–1A4A TERMINAL
11A (splice symbol)	SPLICE CASE
(H S)	HARD STAND
BHBG	COMM CABLE
S1 S2	SYNCHRO TYPE 1 TYPE 2
B1 B2	BENDIX CABLE TYPE 1 TYPE 2 TYPE 3 *
TB	BENDIX TERMINAL BOX
*	SUPPLIED AND INSTALLED BY BX-R (NOT COVERED IN THIS MANUAL)

FIGURE 3-2. OUTSIDE PLANT CABLE SCHEMATIC, GRAND CANARY ISLAND

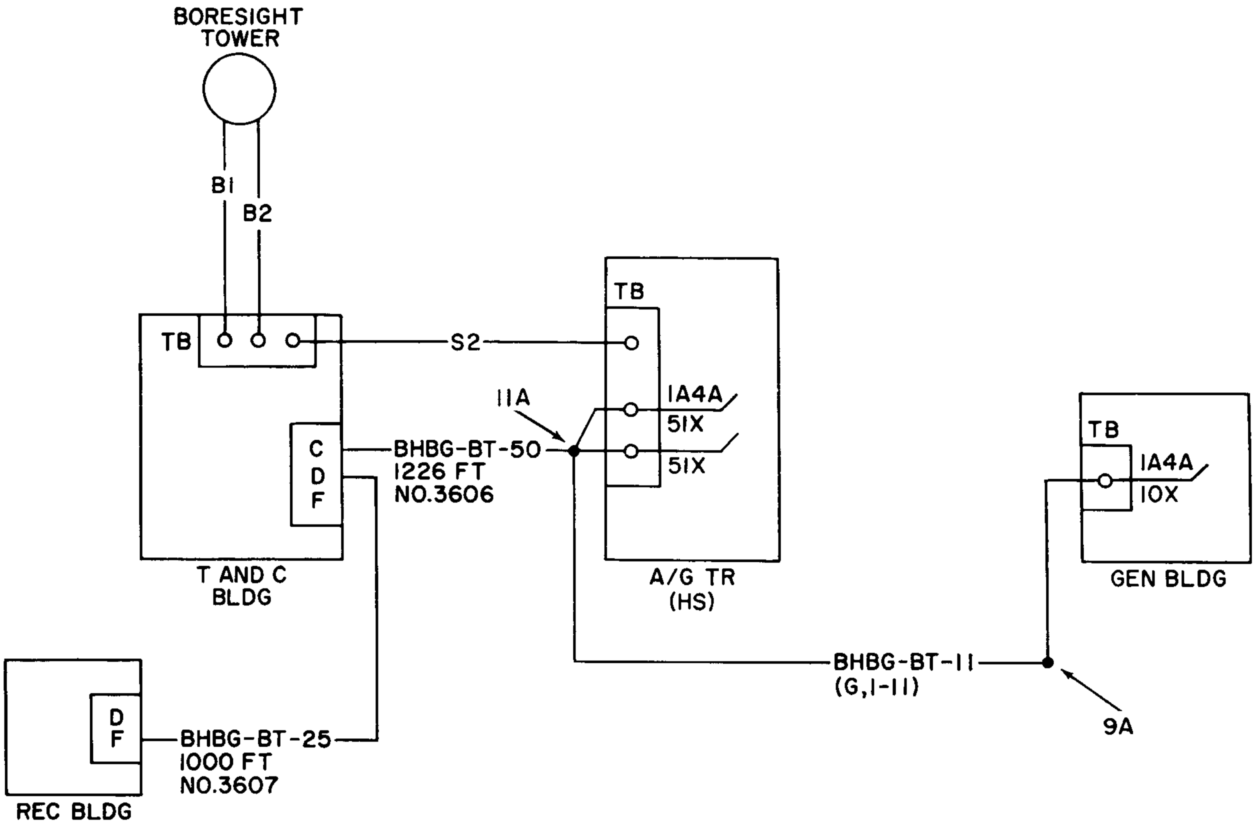


NOTE:
ALL LENGTHS SHOWN ARE APPROXIMATE.

LEGEND:

IA4A / 51X	SIPR-IA4A TERMINAL
IIA	SPLICE CABLE
(HS)	HARD STAND
BHBG	COMM CABLE
SI S2	SYNCHRO TYPE I TYPE 2
BI B2	BENDIX CABLE TYPE I TYPE 2 *
TB	BENDIX TERMINAL BOX
*	SUPPLIED AND INSTALLED BY BX-R (NOT COVERED IN THIS MANUAL)

FIGURE 3-3. OUTSIDE PLANT CABLE SCHEMATIC, KANO

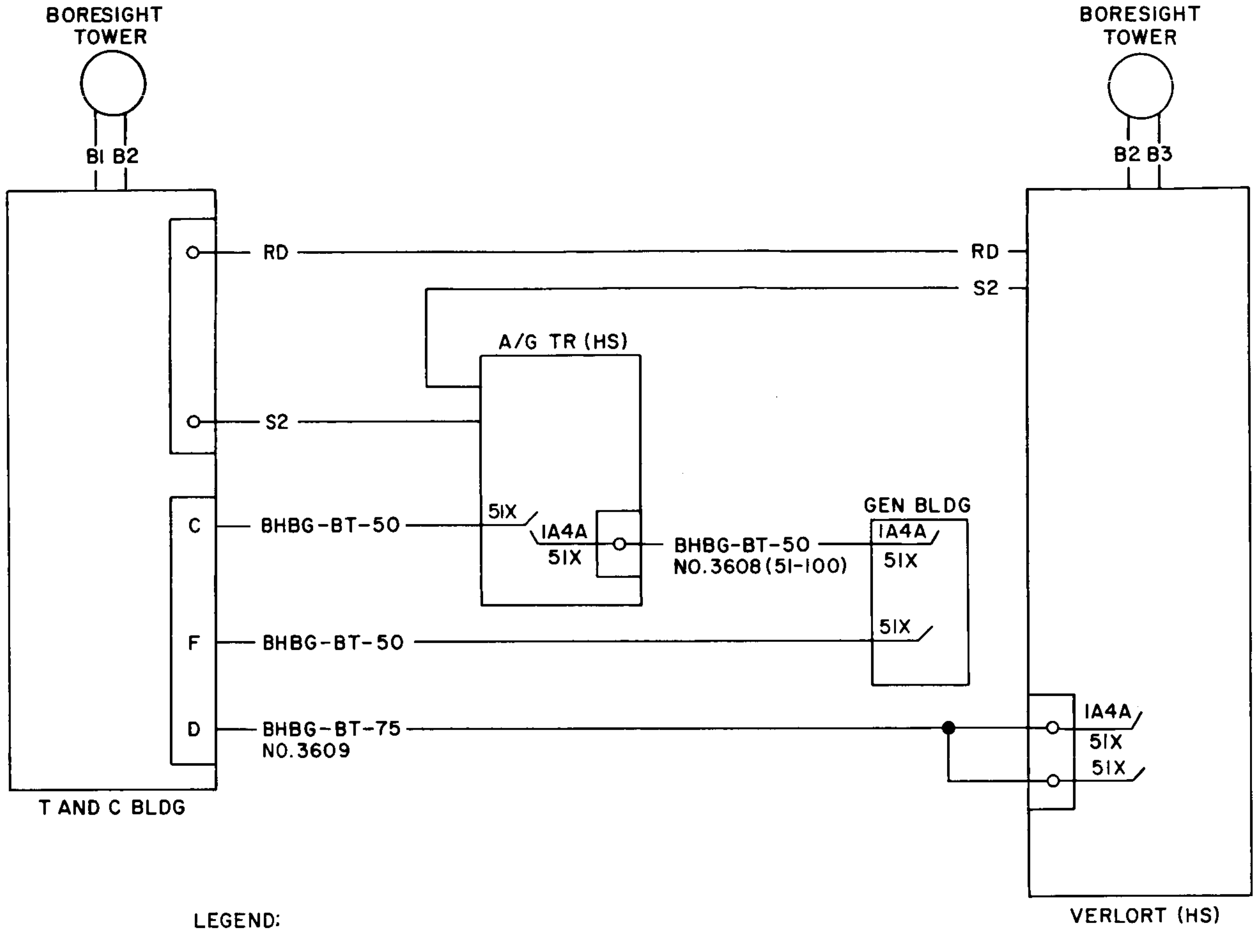


NOTE:
ALL LENGTHS SHOWN
ARE APPROXIMATE

LEGEND:

1A4A / 51X	51PR-1A4A TERMINAL
11A	SPLICE CASE
(HS)	HARD STAND
BHBG	COMM CABLE
S1 S2	SYNCHRO TYPE 1 TYPE 2
B1 B2	BENDIX CABLE TYPE 1 TYPE 2*
TB	BENDIX TERMINAL BOX
*	SUPPLIED AND INSTALLED BY BX-R (NOT COVERED IN THIS MANUAL)

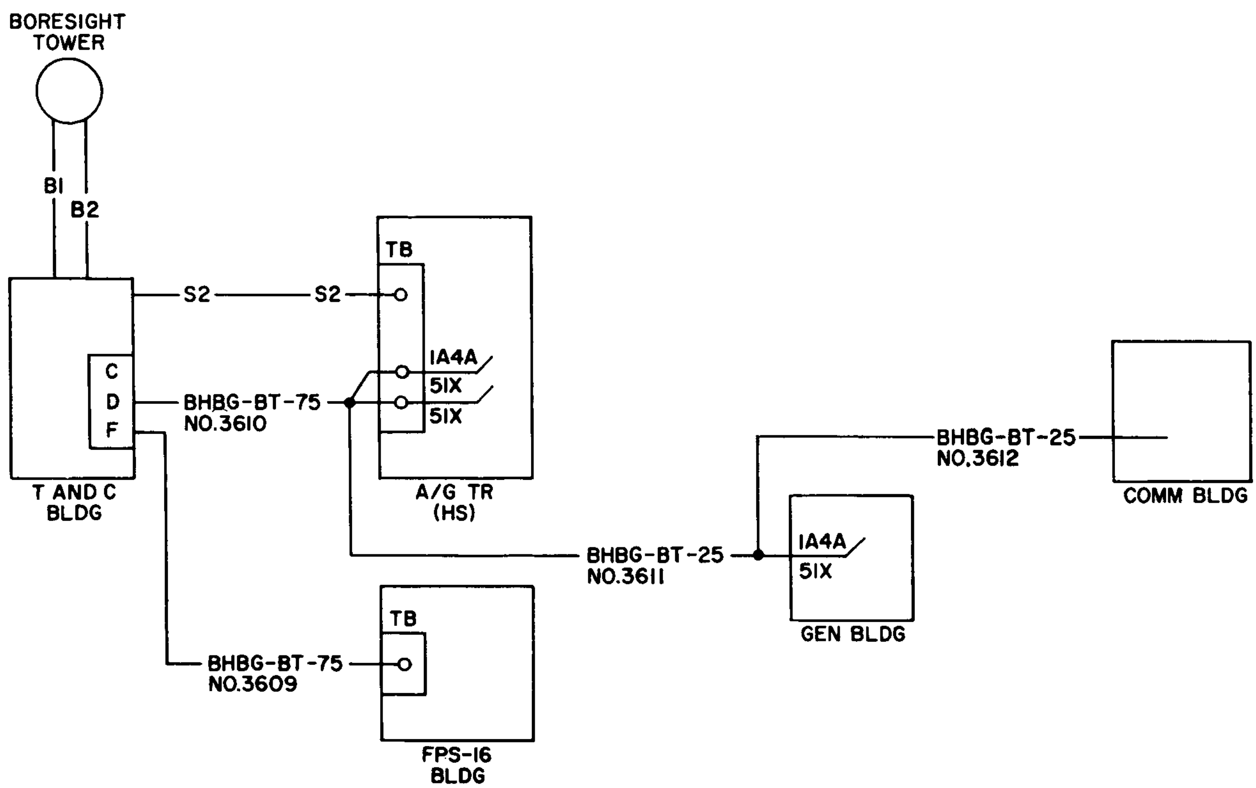
FIGURE 3-4. OUTSIDE PLANT CABLE SCHEMATIC, ZANZIBAR



LEGEND:

RD	RADAR DISPLAY (PLOTBOARD) CABLE
1A4A/51X	51PR-1A4A TERMINAL
—●—	SPLICE CASE
(HS)	HARD STAND
BHBG	COMM CABLE (SUPPLIED BY PMG)
S1 S2	SYNCHRO TYPE 1 AND 2
B1 B2	BENDIX TERMINAL BOX

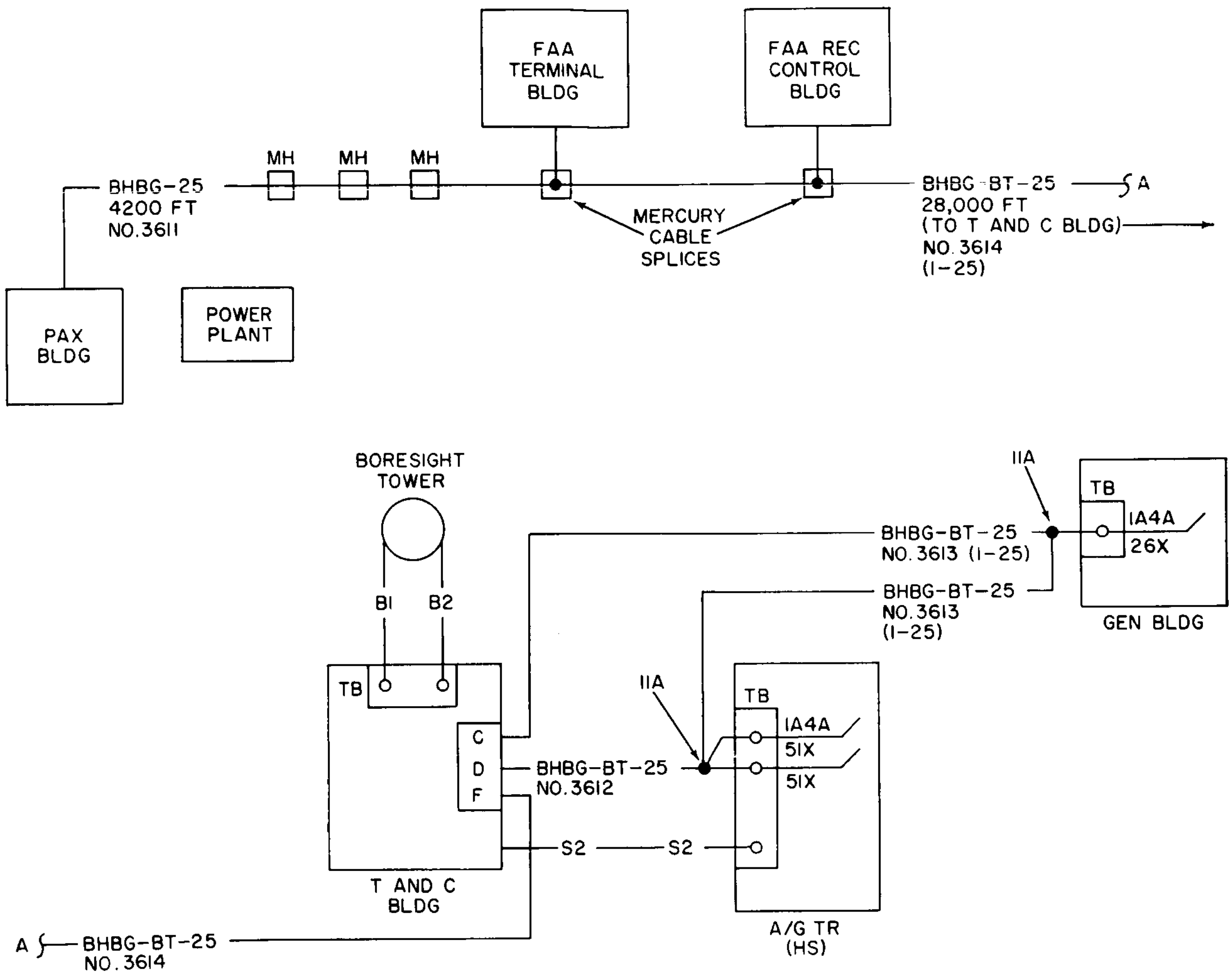
FIGURE 3-5. OUTSIDE PLANT CABLE SCHEMATIC, MUCHEA



LEGEND:

IA4A / 5IX	5IPR-IA4A TERMINAL
—●—	SPLICE CASE
(HS)	HARD STAND
BHBG	COMM CABLE (SUPPLIED BY PMG)
S2	SYNCHRO TYPE 2
TB	BENDIX TERMINAL BOX
BI B2	BENDIX TABLE TYPE I AND 2 *
*	NOT COVERED IN THIS MANUAL

FIGURE 3-6. OUTSIDE PLANT CABLE SCHEMATIC, WOOMERA

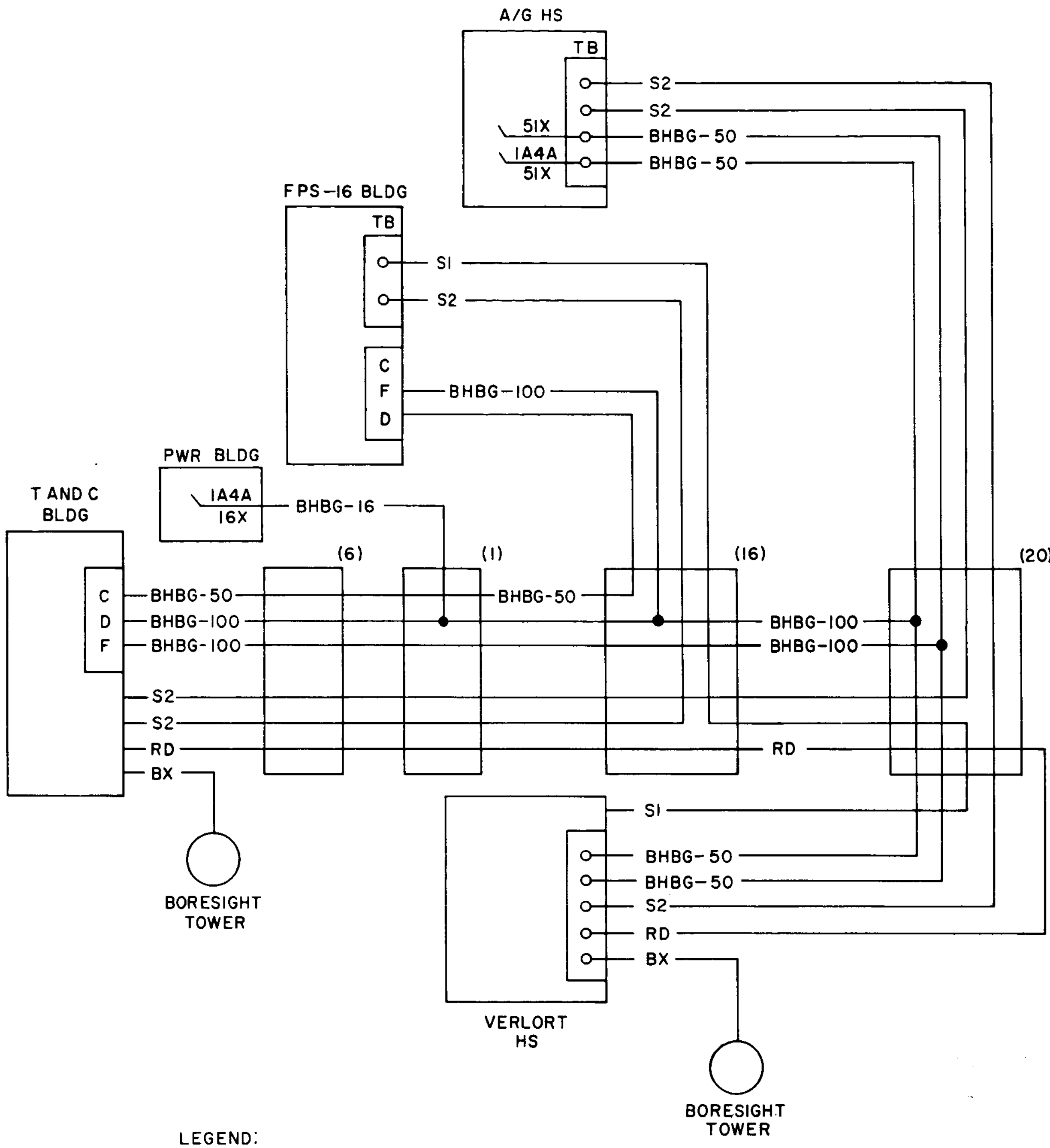


NOTE.
ALL LENGTH SHOWN ARE APPROXIMATE.

LEGEND:

1A4A/51X	51PR-1A4A TERMINAL
11A	SPLICE CASE
(HS)	HARD STAND
BHBG	COMM CABLE
9Z	SYNCHRO TYPE 2
B1 B2	BENDIX CABLE TYPE 1 AND 2 *
TB	BENDIX TERMINAL BOX
*	NOT COVERED IN THIS MANUAL

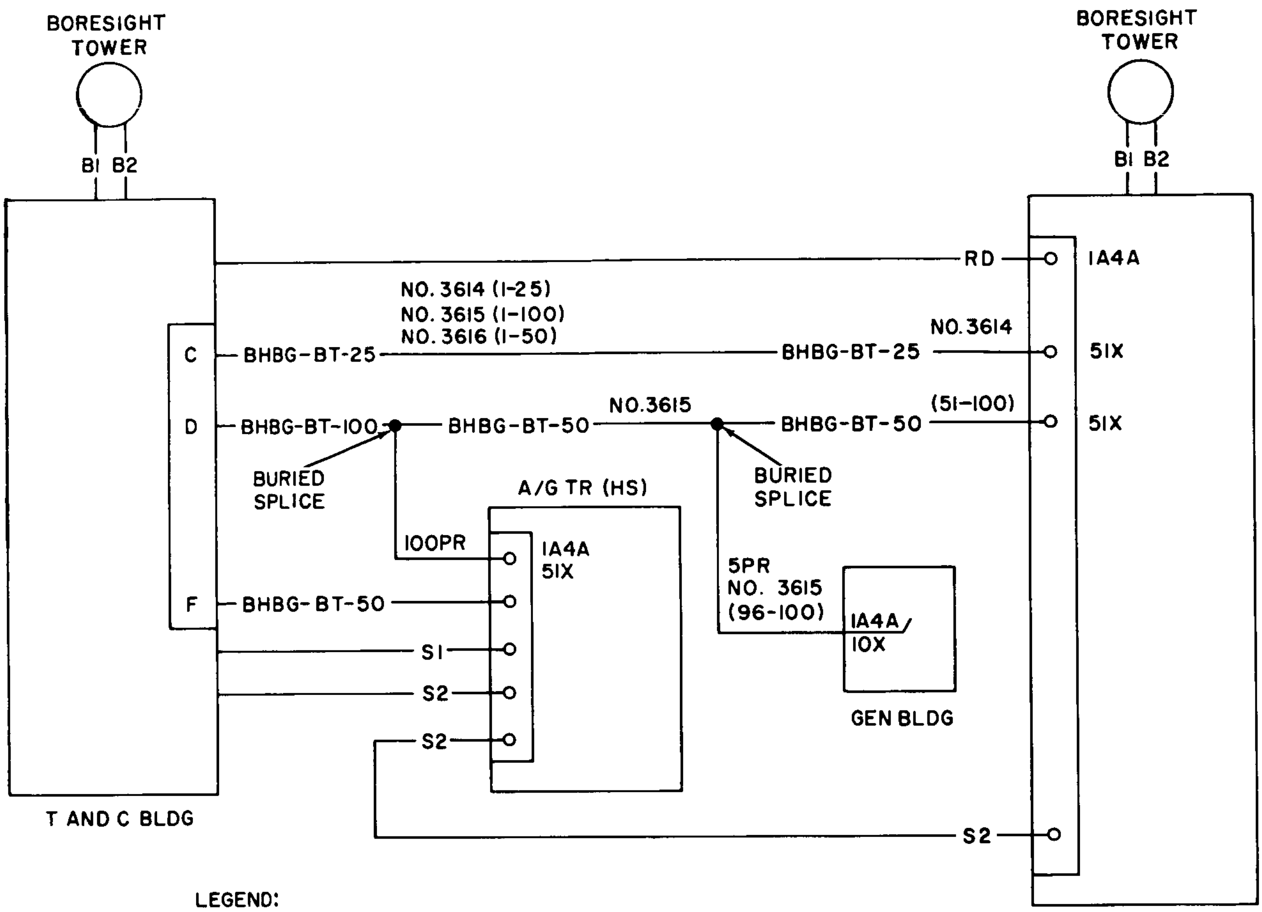
FIGURE 3-7. OUTSIDE PLANT CABLE SCHEMATIC, CANTON ISLAND



LEGEND:

$\frac{1A4A}{51X}$	51 PR-1A4A TERMINAL
—●—	SPLICE CASE
HS	HARD STAND
BHBG	COMM CABLE
S1 S2	SYNCHRO TYPE 1 TYPE 2
TB	BENDIX TERMINAL BOX *
BX	BENDIX SPECIAL CABLE *
*	NOT COVERED IN THIS MANUAL

FIGURE 3-8. OUTSIDE PLANT CABLE SCHEMATIC, GUAYMAS



LEGEND:

RD	RADAR DISPLAY (PLOTBOARD) CABLE
1A4A/ 51X	51 PR - 1A4A TERMINAL
—●—	SPLICE CASE
(HS)	HARD STAND
BHBG	COMM CABLE
S1 S2	SYNCHRO TYPE 1 AND 2
B1 B2	BENDIX CABLE TYPE 1-2 AND 3
TB	BENDIX TERMINAL BOX
*	NOT COVERED IN THIS MANUAL

FIGURE 3-9. OUTSIDE PLANT CABLE SCHEMATIC, HAWAII

SECTION 4. SYSTEM OPERATION

4.1 CABLE RECORDS

Cable records will be kept at each Mercury site. The records contain information on cable numbers, pair counts, and pair assignment. The use of the cable records is detailed in MG-102, *Plant Operating and Maintenance Procedures.* The *Cable Pair Assignment Record,* Form MP-268, is also illustrated in MG-102.

4.2 COMMUNICATIONS CABLE INDEX

Bermuda (Town Hill)	No. 0806	58-99	Prs	Telemetry Rec Bldg to Existing
	0807	25-32		152-19TA Cable Route
	0808	1-50		(Prospect to Harrington)
(Coopers Island)	No. 087	1-100	Prs	Kindley to Mercury T & C Bldg (All Intrasite Mercury Cable Prs are in H-(House) cable.)
Canary	No. 3604	1-100	Prs	T & C Bldg to A/G HS
		90-100		A/G HS to Gen Bldg
		1-75		T & C Bldg to Verlort HS
Kano	No. 3605	1-50	Prs	T & C Bldg to A/G HS
	3606	1-25		T & C Bldg to Rec Bldg
	3607	1-11		A/G HS to Gen Bldg
Zanzibar	No. 3606	1-50	Prs	T & C Bldg to A/G HS
	3607	1-25		T & C Bldg to Rec Bldg
	G	1-11		A/G HS to Gen Bldg
Muchea	No. 3608	1-50	Prs	T & C Bldg to A/G HS
		51-100		(T&C Bldg to Gen Bldg (Looped in & out)
	3609	1-75		T & C Bldg to Verlort HS
Woomera	No. 3609	1-75	Prs	T & C Bldg to FPS-16 Bldg
	3610	1-75		T & C Bldg to A/G HS
	3611	1-25		A/G HS to Gen Bldg
	3612	1-25		Gen Bldg to Comm Bldg

(Cont'd)

4.2 COMMUNICATIONS CABLE INDEX (Cont'd)

Canton Island	No. 3611	1-25 Prs	PAX to FAA Control Bldg
	3614	1-25	FAA Cont Bldg to Mercury T & C
	3612	1-25	T & C Bldg to A/G HS
	3613	1-25	T & C Bldg to Gen and Looped to A/G HS
Guaymas	No. 3614	1-25 Prs	T & C Bldg to Verlort HS
	3615	1-50	T & C Bldg to A/G HS
		51-100	T & C Bldg to Verlort HS
		96-100	Looped into Gen Bldg
	3616	1-50	T & C Bldg to A/G HS

SECTION 5. MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

5.1.1 Safety—General

In excavating for cable repair or replacement, or for trouble locating, first determine the exact location of any other cables or buried installations in the same trench or near vicinity.

Extreme care must be exercised to avoid damage or unnecessary disturbance to cables, other than those being repaired. In all cases, consult the site drawings for available information. The maintenance man must check into the voltages involved before working on any wire or cable. When in doubt as to whether a hazardous condition exists, consult the site manager, or site drawings.

When performing any maintenance operations, whenever possible, disconnect all power by opening the switches or circuit breakers, removing fuses, or disconnecting wires or cables. Also de-energize any neighboring circuits which can be contacted accidentally. All switches, circuit breakers, and removed fuses will be tagged, using Tag, Form MP-229, DO NOT TOUCH —MAN WORKING (See Figure 5-1), or Tag, Form MP-206, DANGER (See Figure 5-2), as required. See MG-102, *Plant Operating and Maintenance Procedures.*

Be certain that the body, clothing, the equipment, and the surroundings, are absolutely dry when servicing equipment. Keep wet clothing away from the vicinity of any electrical circuit. Stand on a rubber mat or other insulating materials, or wear dry, rubber, foot gear.

Always remember that a circuit normally carrying a harmless current may be shorted to a dangerous voltage, and that ground connections to a normally grounded circuit may fail.

Unused cable and wiring must be properly reeled and stowed where they will not interfere with normal operation and maintenance procedures.

As a protection to other maintenance men, be sure to indicate and leave a visual record of any circuit changes that are made in the field.

When servicing during inclement weather, erect temporary shelters to keep equipment and clothing dry.

When servicing during electrical storm, be sure that all lines and equipment are well grounded.

When using jumper wires of any type, be sure that they are equipped with proper end connectors, such as bull dog, or alligator-type clips.

5.1.1.1 *Manhole Safety*

Open manholes must be guarded at all times with a manhole guard or barricade. These and other warning devices should be set up at the manhole before the cover is removed.

Manhole ladders must be inspected each time before using and must be replaced promptly when found in a deteriorated condition. When the bottom of the ladder is in water, or otherwise invisible, it must be drawn up for inspection.

When working in manholes, care must be taken to prevent damage to cables in setting up the pulling apparatus or in placing tools of any kind. Do not step on cables when entering or leaving a manhole.

Every manhole or cable vault opened for the first time during the day or reopened after having been closed for any length of time, must be tested to determine if gas in dangerous quantity is present or if there is an oxygen deficiency. A manhole must be entered only after test indicates that the atmosphere is safe.

Tests must be made immediately upon removing the cover. Never enter a manhole that has not been tested for the presence of gas.

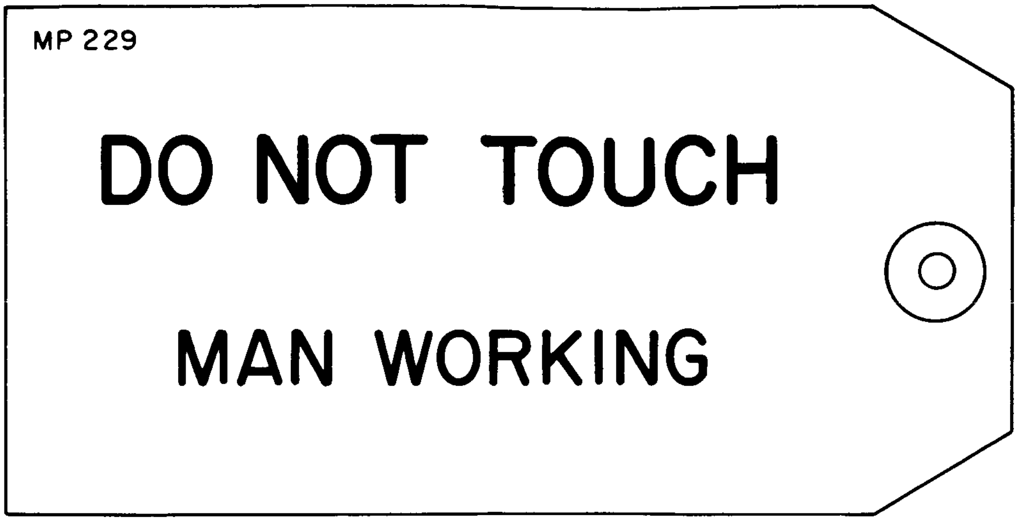


FIGURE 5-1. TAG, FORM MP 229, DO NOT TOUCH, MAN WORKING

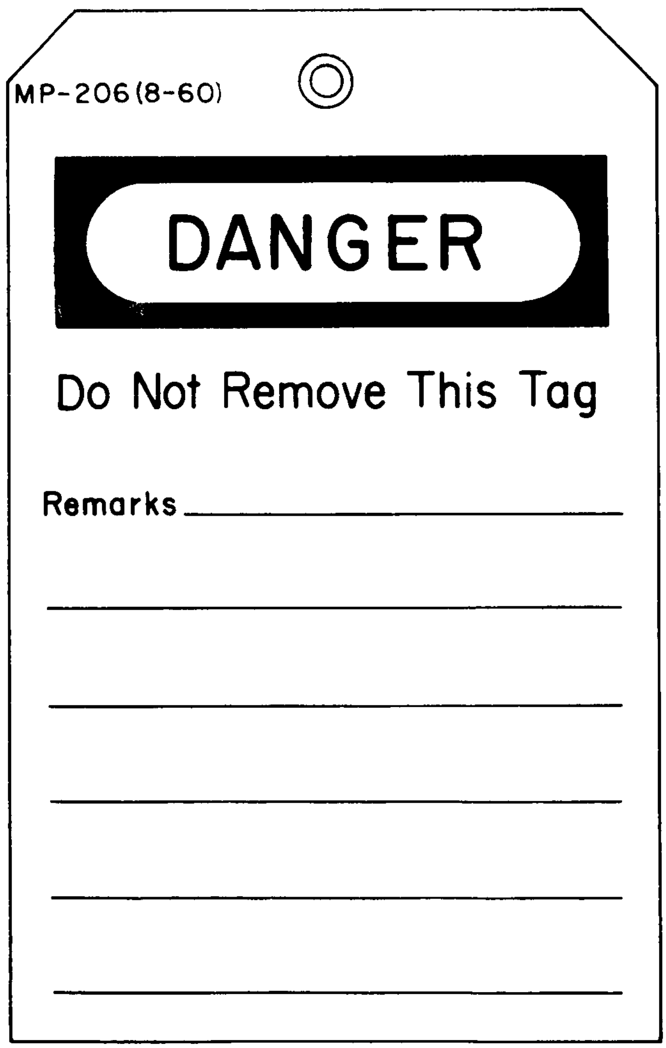


FIGURE 5-2. TAG, FORM MP 206, DANGER

A test for carbon monoxide (includes testing for hydrogen sulphide) may be made simultaneously with those made for other combustible gases. Do not let the end of the hose on a gas detector enter water, if present, in the manhole.

The test must be made at the point where a man's head will be, while working in the manhole. If sufficient water is present to require pumping, make the test about one foot above the level of the water.

The manhole must be ventilated with a sail to supply fresh air to the workman, except when a power blower is employed.

If the test made on opening or reopening the manhole is satisfactory, the manhole or vault may be entered and worked in.

5.1.1.2 *Additional Tests*

Additional tests must be made as follows:

a. When each crew begins work.

b. At intervals not to exceed 2 hours.

c. When the manhole is covered with a tent or tarpaulin, it must be tested at intervals not to exceed 1 hour. Place the tent or tarpaulin so that an opening is left in the covering for ventilation.

d. After the manhole has been pumped: The removal of water may permit gas to flow into the manhole. Tests must be made just above the duct entrances. If a test indicates that gas is entering, ventilate the manhole with a power blower.

e. Testing after removal of duct plugs: Immediately upon the removal of the duct plugs, make a test just above the opened duct. If the test indicates that gas is entering, ventilate with a power blower.

Subsequent tests may be made with a gas (hot wire) indicator, carbon-monoxide detector, or carbon-monoxide indicator while in the manhole.

When more than the allowable trace of gas is found on the initial test, the manhole must be ventilated with a power blower. Then make a second test and if it tests satisfactorily, the manhole may be entered. If gas is again found on the second test, ventilate the manhole with a power blower until it has been definitely established that no more gas is entering or until work in the manhole has been completed and the cover is about to be replaced. While working in a manhole being ventilated with a power blower, test the atmosphere every hour. Make the test away from the direct blast of the blower.

Operate the blower outside of the manhole covering. If the blower stops, leave the manhole at once and do not re-enter until ventilation has been restored and the atmosphere tests satisfactorily.

5.1.2 Maintenance Testing—General

The principles of line testing are basically the same, regardless of the type of line to be tested, or the type of test instrument used. The main purposes of testing are as follows:

a. To determine the condition of a line or circuit.

b. To detect any existing trouble, and to make a rapid and correct analysis of the fault.

c. To locate the fault and clear it with as little interruption to service as possible.

d. All lines should be tested during construction or installation as part of maintenance routines and when trouble develops.

5.1.2.1 *Routine Tests*

Proper maintenance requires routine tests to be conducted at regular intervals on all working lines to ensure uninterrupted service. Routine maintenance tests must be coordinated with other outside plant routines.

5.1.2.2 *Construction or Replacement Tests*

Specific tests are made while the construction of a line is in progress. For example, testing of sections of underground cable before splicing. The lines to be tested vary from a few hundred feet of wire on a reel, to 5 miles of working cable.

Reels or wire and lengths of cable are tested before installation to determine their condition, and to ensure serviceability, especially when the wire or cable is reused. Testing dead (unused) circuits during construction is a check on correct installation, and a means of disclosing faults which may have developed in the placing or stringing of the cable or wire. Moreover, the records of such tests furnish the basis for proper maintenance of the completed line.

5.1.2.3 *Trouble Tests*

Trouble tests are conducted when a working line is reported in trouble. The tester must analyze the fault, determine its location, and see that it is cleared with the least possible interruption of service.

The types of defective pairs which may be found in cables are illustrated below. The defect may consist of a short-circuited pair, an open pair, a grounded pair, a crossed pair, or combinations of these faults. The faults may be found either within a section of cable or within a splice.

The two wires of a pair in contact with each other.

A break in one or both of the wires of a pair.

One or both wires of a pair in contact with the sheath of the cable or other grounded object.

Two wires, each of a different pair, in contact with each other.

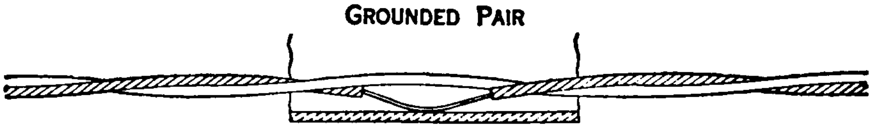
SHORT CIRCUITED PAIR

The two wires of a pair in contact with each other.

OPEN PAIR

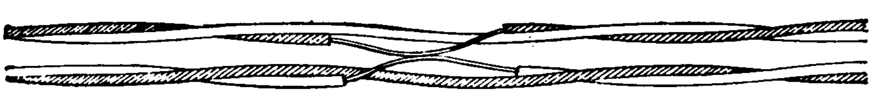
A break in one or both of the wires of a pair.

GROUNDED PAIR



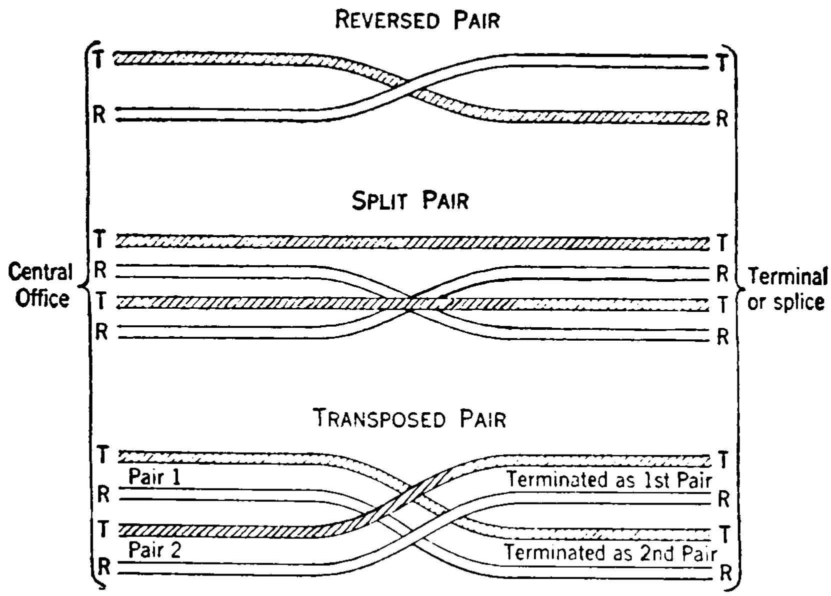
One or both wires of a pair in contact with the sheath of the cable or other grounded object.

CROSSED PAIR



Two wires, each of a different pair, in contact with each other.

Other faults due to mistakes in splicing or terminating include a reversed pair, a split pair, or a transposed pair. These are shown below:



An insulation-resistance test should be made on new cable before using it for repairs and again, after splicing the cables. In determining cable faults, the first step is to make an insulation-resistance test. If this test is not satisfactory, tests must be made for grounds, short circuits, and open circuits.

5.2 TEST PROCEDURES

5.2.1 Use of 1A Toll Test Unit

A 1A toll test unit consisting of a voltmeter and telephone circuit, is rack mounted in the VF patch bay at the telemetry and control (T & C) building of each Mercury site. This unit provides means for making voltmeter and talking tests at the primary appearance of the cable pairs.

The unit is shown on DP-11159 of the site drawings and the circuit description is included on this drawing. The unit is also covered in the Mercury test equipment manual ME-621, *Miscellaneous Test Equipment*.

5.2.1.1 *Continuity Test and Resistance Measurements*

The continuity and resistance of a circuit may be tested by connection to the voltmeter and testing battery. The (BAT) or the (REV BAT) key is operated to close the circuit through the voltmeter and the connected circuit. Resistance to ground on either tip or ring conductor may be measured by using the (TEST TIP) or (TEST RING) key. The choice of the 100,000-ohm or the 1000-ohm voltmeter should be determined by the magnitude of the resistance being measured, because the results are more accurate when the resistance of the voltmeter is nearly equal to the resistance being measured. The 1000-ohm voltmeter should be used when measuring resistances less than 10,000 ohms. If the voltmeter reading is in excess of 135 volts when the MA1000 key is normal, the resistance is less than 10,000 ohms and the 1000-ohm voltmeter should be used.

5.2.1.2 *Insulation Resistance*

Insulation resistance may be measured in the same way as conductor resistance. In general, the measured resistance will be sufficiently high to justify neglecting the effects of the testing-circuit resistors in series with the battery and the voltmeter.

When capacity is present in the circuit being tested, the charging of this capacity will cause the voltmeter deflection to be momentarily higher than its final value. The maximum amplitude of the deflection will be approximately proportionate to the capacity being charged.

A conductor cross is indicated, by means of a voltmeter insulation test, by a disproportionately large momentary deflection compared with a similar measurement on a normal conductor. The momentary deflection increases because of the capacity added by the crossed conductor. The conductor with which the first conductor is crossed may be found by means of voltmeter measurements made between the faulty conductor and other conductors.

5.2.1.3 *Capacitance Tests*

Since in a circuit of capacity and resistance the deflection of a voltmeter caused by the charging current is proportional to the capacity, such deflections serve as an indication of the capacity between line conductors or a line conductor and ground. Tests may be made between conductors connected to either the VM A or VM B jacks or, with the TEST TIP or TEST RING keys operated, between such conductors and ground. The operation of the BAT key causes a deflection as the capacitance is charged. Successive deflections in opposite directions may be secured by alternate operations of the BAT and REV BAT keys.

5.2.2 Use of 76C Test Set—Identifying Conductors

The paragraphs below outline a method of identifying conductors in nonworking and working cables with the use of a 76-type test set. The test set is further described in paragraph 5.5 of this section.

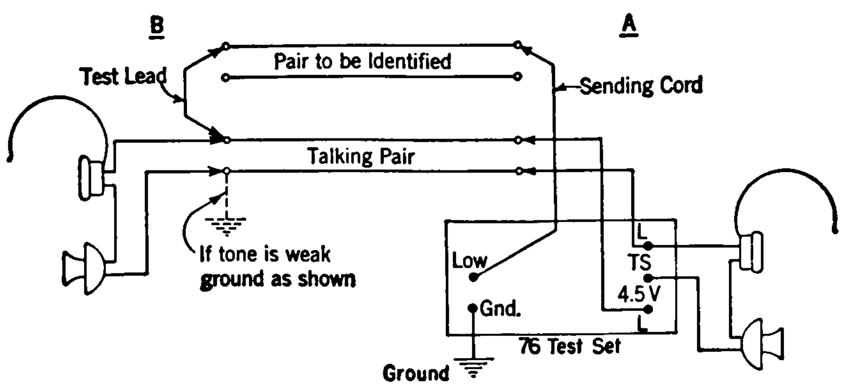
5.2.2.1 *Nonworking Cables*

In nonworking cables, make the connections at the sending end A and at the identifying end B, as illustrated below. Then proceed as outlined:

a. At end A, select a pair to be identified and connect the sending cord to one wire of the pair. The right-hand key should be in the TLK (talking) position. Operate the left-hand key to the SIG (signal) position. Identifying current (tone) will be heard in the talking circuit, indicating to end B that a pair is ready to be identified. Then operate the key to the SND (sending) position.

b. At B, run over the conductors until the pair with tone is located.

c. After the first pair has been located, proceed with the identification of other pairs in a similar manner. If the cable is very short, the tone may be too weak to identify the conductors. In this event, the tone can be increased by placing ground on the talking pair at end B, on the side opposite the one to which the test lead is connected, as indicated by the dotted lines in the sketch below.



5.2.2.2 *Working Cable*

In working cables, the method employed depends on the type of circuits working in the cable.

In a cable or group of conductors in a cable containing no special circuits, tone may be sent from the splice and identified at a termination. The method described below can be used under the following conditions:

a. In a working cable that does not contain special circuits.

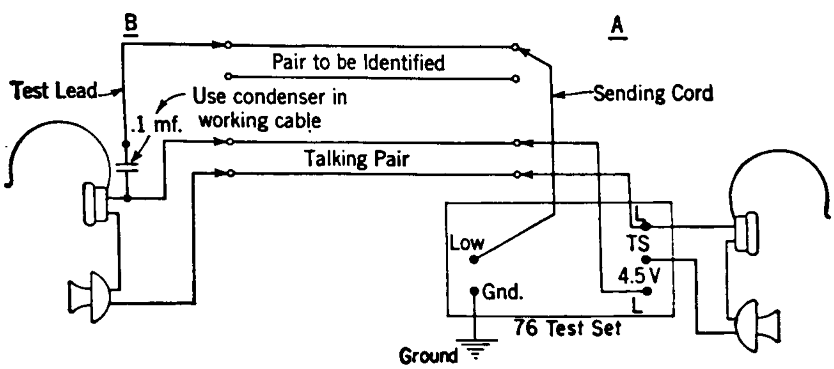
b. In a group (or complement) that does not contain special circuits, provided that the group (or complement) can be identified and segregated.

Make the connections at the sending end A and at the identifying end B, as illustrated below. Then proceed as outlined:

b. At B, run over the conductors under test using the lead from the 1/10-mf capacitor, until the pair with tone is located.

c. After the first pair has been identified, proceed with the identification of other pairs in a similar manner.

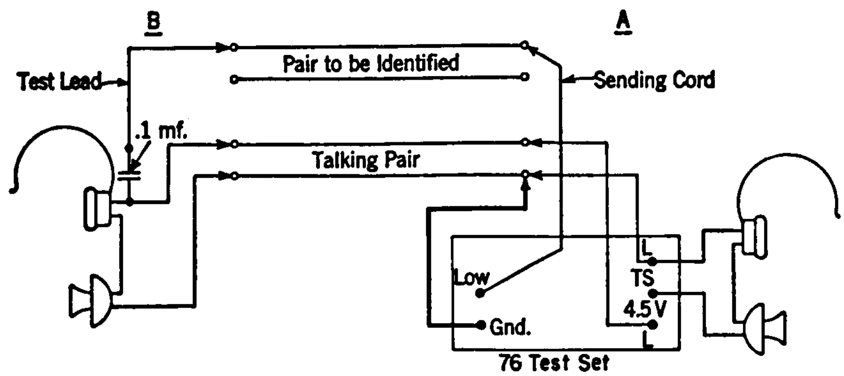
If the conductors are being identified at a main frame by running a test point along the springs, do not make contact between adjacent springs, because this will cross two working circuits and may result in service interruption.



a. At A, select a pair to be identified. With the left-hand key in the LIS (listening) position, connect the sending cord to one wire of the pair and listen to determine if the pair is busy. If the pair is idle or spare, operate the left-hand key to the SIG position and then to the SND position. In the SIG position, tone will be heard in the talking circuit indicating that the pair is ready to be identified.

In identifying conductors in a cable containing working pairs, care should be exercised at ends A and B to avoid contact with any wire in a group or complement that may contain special circuits.

If the cable is short, the tone heard may be too weak, making identification difficult. In this event, the tone can be increased by connecting the GND post to one side of the talking circuit instead of to ground at A. As indicated below, the connection should be made to the side opposite the one to which the test lead is connected at B.



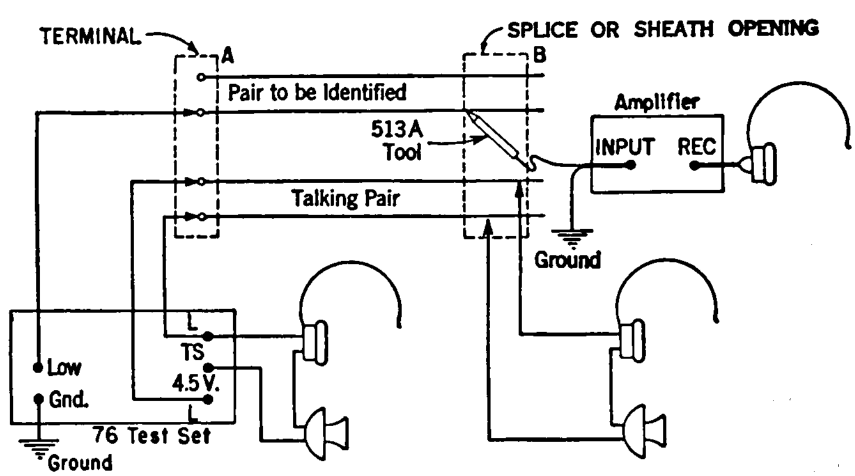
5.2.3 Use of 91A Test Set—Identifying Conductors

5.2.3.1 *General*

In a cable or group of conductors in a cable containing special circuit, tone may be sent from a termination where the identity of the circuits is known. The method described below may be used under the following conditions:

a. After a listening test is made on spare conductors and conductors used for subscriber circuits or interoffice trunks.

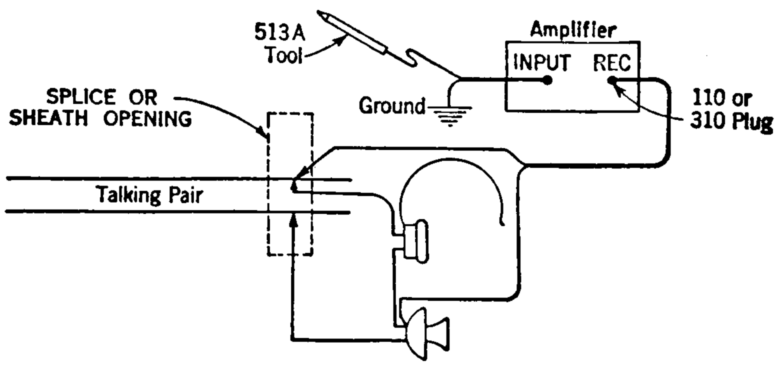
b. After authorization has been obtained to turn down or open conductors that are assigned to special circuits. At the identifying end, the conductors must be identified by means of an amplifier and a probe. The connections at the sending end A and at the identifying point B are made as illustrated below.



The previous diagram shows the amplifier and the talking set at the identifying end, operated with separate receivers. For convenience, the talking set and the amplifier can be connected, as shown below, which requires the use of only one receiver.

conductors with the 513A tool until the conductor with tone is located.

c. After the first pair has been identified, proceed with the identification of other pairs in a similar manner.



5.2.3.2 *Procedure*

The conductors should be identified as follows:

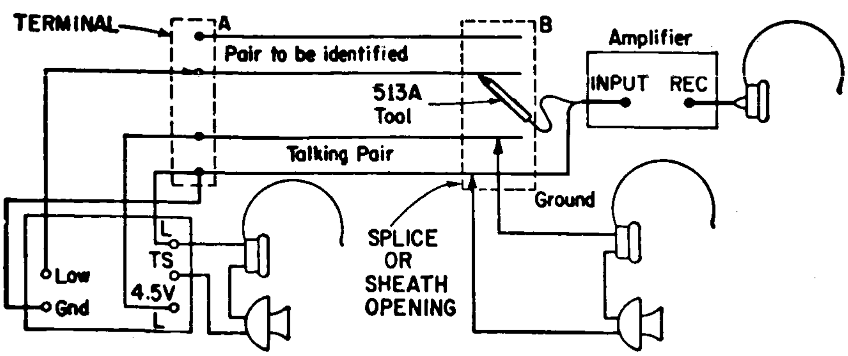
a. At the sending end, select a conductor to be identified. With the left-hand key in the LIS position, connect the sending cord to one wire of the pair and make a listening test. If the pair is idle or spare, operate the key to the SIG position and then to the SND position. In the SIG position, tone will be heard in the talking circuit, indicating that the pair is ready to be identified.

b. At the identifying end, probe through the

If difficulty is experienced in identifying conductors because of induced 60-cycle power noise on the wires, the interference may be reduced by making one of the following changes in the connections:

(1) Disconnect the ground lead of the amplifier from ground and allow it to hang free, or

(2) Disconnect the ground lead of the amplifier from ground and connect it and the ground lead of the 76-type set to the same side of the talking pair, as illustrated below.



5.3 CORRECTIVE MAINTENANCE

Corrective maintenance includes the repair or replacement of cable, removal and replacement of splice cases, and the repair of manholes and conduit.

5.3.1 Replacing Cable Sections

5.3.1.1 *General*

No splices are permitted to fall within a road crossing, airplane runway, or any vehicular pass. A fault located in such an area must be repaired by replacing the section of cable involved and splicing out on each side of the road, runway, or pass.

CAUTION

> In all cases, a minimum separation of 12 inches in all directions must be kept between PAP cables and power cables.

5.3.1.2 *Tools and Materials*

a. Bars, digging and tamping

b. Cable, (as required)

c. Cable jacks (two) and axle

d. Pick, drifting, 5-lb

e. Plank, creosoted

f. Shovels, round point

g. Splice cases, type 9A

h. Sand or fine gravel

5.3.1.3 *Procedure (Refer to Paragraph 2.2.2)*

a. Be sure that proper cushioning is maintained when it is necessary to replace a buried cable, or a portion of the same. In the event that this protection has been disturbed, or partially removed while digging up cable for repairs, before placing the cable make certain that the trench has a well-tamped cushion of sand or fine gravel.

b. The cable should preferably be payed off from a reel mounted on a vehicle, but may also be placed by pulling off reels on stationary mountings. If the latter method is used, extreme care must be taken to avoid abrading (scraping off) the sheath. Do not place the cable by rolling the reel or pulling the cable over the reel ends.

c. Do not pull cable over, or leave the cable lying on rocks, stones, or rough gravel.

d. As soon as the cable is laid, observing minimum depths and separations discussed in paragraph 5.3.1.1. The sheath should be inspected for any damage which may have been made during placement.

e. Repair minor abrasions according to paragraph 5.3.2.1.

f. If the inner polyethylene sheath has been broken, remove enough of the sheath to permit installation of the 9A splice case, as described in paragraph 2.3.2.3, a.

g. When laying new cable, a lap of 3 feet at the real end is to be left to facilitate splicing.

h. Upon completion, cover the placed cable with a top cushion of tamped sand or fine gravel. (See paragraph 2.2.2.3.)

i. Replace cable marker.

j. Mark changes or additions accurately on the outside plant site drawings.

5.3.2 Repairing PAP Cable—Minor Defects

5.3.2.1 *General*

Use the following procedure for repairing defects or cracks, where the inner polyethylene sheath has not been broken and no moisture has entered the cable.

Where moisture has entered, it is necessary to open the cable. Remove enough sheath to permit installing the 9A splice case, as discussed in paragraph 2.3.2.3, a.

5.3.2.2 *Tools and Materials*

a. Brush, carding

b. Cement, type C

c. Hammer, machinist

d. Tape, aluminum, type B

e. Tape, paper, type B

f. Tape, friction

g. Tape, vinyl, type D

5.3.2.3 *Procedure*

a. Scuff the sheath with a carding brush, covering the area over the defect and 3 inches on each side of the defect.

b. Cover the defect with B-type aluminum tape including 1 inch on each side of the defect. Smooth the tape down with a hammer handle.

c. Paint over the cleaned area and the aluminum tape with C-type cement.

d. Wait a few minutes until the cement is tacky and then wrap the repair with two-half-lapped layers of B-type paper tape applied as smoothly as possible.

e. Cover the paper tape and 1 inch of the sheath on both sides of the repair with one half-lapped layer of friction tape.

f. Complete by covering the above layer with a half-lapped layer of B-type paper tape. If the ends do not stick down firmly, wrap the ends with two turns of friction tape.

g. If the cable is to be buried, finish with an additional half-lapped layer of D-type vinyl tape.

5.3.3 Splicing PAP Cable

5.3.3.1 *General*

Measurements for the layout of splices must be made carefully to avoid unnecessary removal of the sheath, and to simplify the protection of the finished splice.

Splices on buried cable may be made in splicing pits, dug to a depth which will provide specified minimum coverage over the completed splice. When necessary because of weather conditions, splicing operations must be done under shelter, such as a tarpaulin or tent, to keep out moisture, cold, and wind and ensure adequate insulation resistance when the splice is completed. Temperature conditions may necessitate heating the shelter to perform splicing operations. An approved shelter heater should be used. (See paragraph 2.3.)

Rearrangements and additions should be marked on outside plant site drawings.

5.3.3.2 *Tools and Materials:*

a. Bar, digging and tamping

b. Cable racks (or 2-inch x 4-inch lumber)

c. Heater, tent

d. Pick, drifting, 5-lb

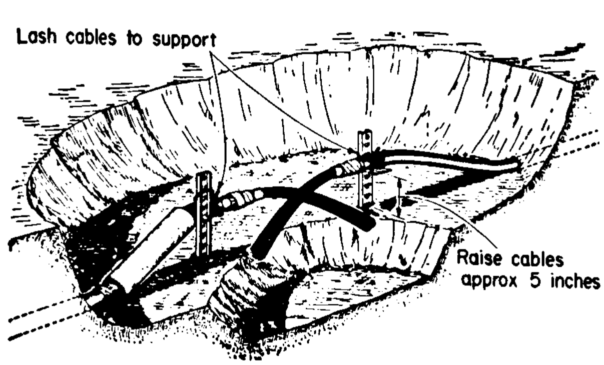
e. Rope, lashing (or twine)

f. Shovel, round-point

g. Tarpaulin (or tent) if required

5.3.3.3 *Procedure*

Excavate to two separate depths, as shown below. The depths must be determined by the placement of the cable, but excavation must be kept to a minimum diameter and depth, particularly under the splice to avoid unnecessary disturbance of the bed.



See paragraph 2.3.2.3 for additional details.

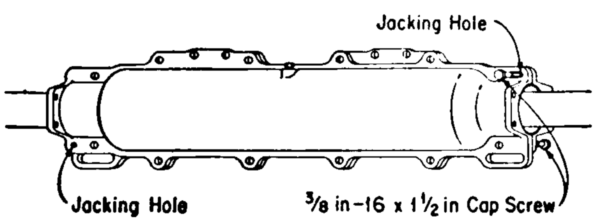
5.3.4 Removing and Replacing Splice Cases

5.3.4.1 *Procedure—Removal of Splice Case*

a. Using the wrench, remove the nuts and bolts from the end collars and from the sides of the cases.

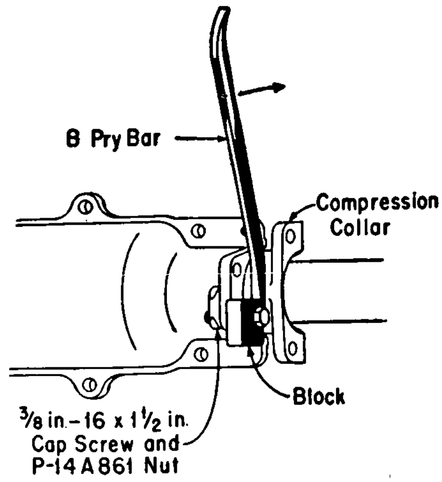
b. Using the pry bar, remove the end collars from the cases, taking care to avoid scratching, marking, or breaking the ears or collars on the splice cases.

c. Insert four mounting bolts (3/8 inch-16 by 1-1/2-inch cap screws) in each of the jack holes provided for that purpose. Tighten alternately, about two turns on each bolt until one or both cases are free from the cable.



d. If only one of the cases is freed, assemble the pry-bar block in one of the end-collar, mounting holes. Place an end collar on the sheath adjacent to the case to prevent damage to the cable. Using the pry bar, loosen the case from the sheath. The block can be rotated to provide the necessary spacing for inserting the end of the bar as shown below.

e. After one end of the case is loosened, the other end usually can be removed by alternately raising and lowering the freed end of the case. If the cable remains tight in the case, repeat procedure to release it at the other end.



5.3.4.2 *Procedure—Replacing Splice Case*

a. Remove and discard enough of the old sealing cord from the case grooves to permit the placing of new cords. It is not necessary to remove all of the cord. The sealing tape in the end seals may be left, if most of it adheres in one solid piece around the cable.

b. Remove the outer sealing washers; remove the old end seals, and make up a new tape seal.

c. Replace the sealing washers and close the case.

d. Refer to paragraph 2.3.2.9 for further details.

5.3.5 Establishing Talking Circuits for Maintenance

5.3.5.1 *General*

In many splicing and maintenance operations, it is necessary to have a circuit for talking between sheath openings, splices, and terminations.

Spare conductors should be used whenever possible. Between adjacent splices it is generally possible to select a tracer or marker pair, if it is spare.

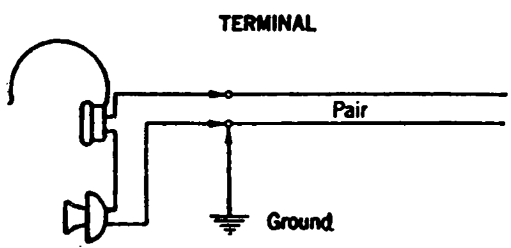
The talking circuit can be identified with tone, following the procedures given in paragraph 5.2.2.

5.3.5.2 *Procedure — Use of 76 — Type Test Set*

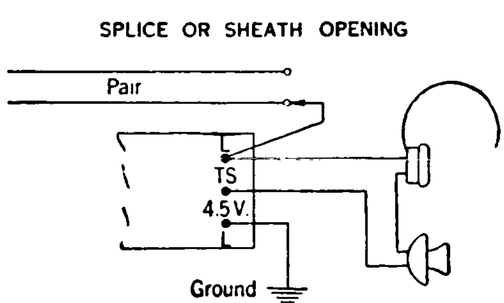
a. *Nonworking Cable*

Selecting pair from terminal by grounding: If a talking circuit is required from a distribution terminal to a splice or sheath opening nearby, it may be desirable to select the pair at the terminal and identify it at the splice. If the test set is to remain at the splice, the pair must be grounded at the terminal and identified as a ground at the splice. The procedure is as follows:

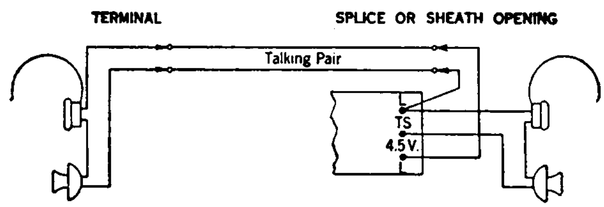
(1) At the terminal, select a pair, connect a talking set across it, and ground one side, as shown below.



(2) At the splice or sheath opening, connect the talking set, as shown below. Set the keys at LIS and WS-WAIT; then use the scissors or test pick to make contact with the wires until the buzzer in the set operates, indicating that the pair has been located.

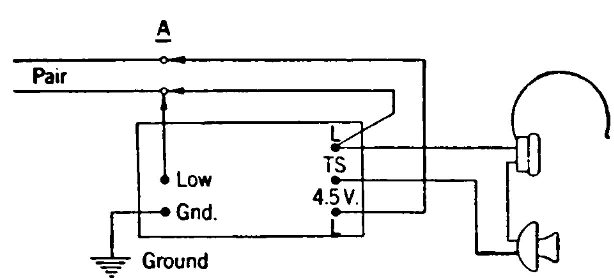


After the pair has been located at the splice or sheath opening, clear the ground and connect the lower L post to the talking pair. This will again operate the buzzer in the set. Shift the key from WS-WAIT to TLK, which stops the buzzer. Clear the ground at the terminal. The final connections must be as follows:

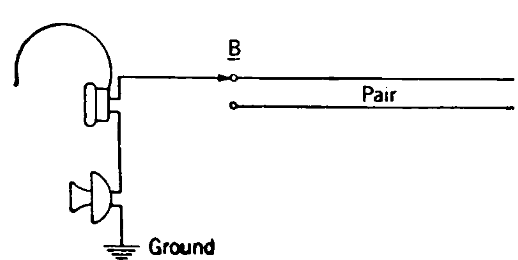


Selecting pair by tone: If the talking pair is to be selected from a splice or a large terminal, it is generally desirable to use tone to identify it at the other end. Designating the two places as A and B, each of which may be a splice, sheath opening, or termination, the general procedure is:

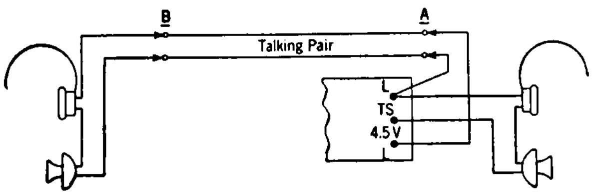
(1) At the sending end A, make the connections as illustrated below and send tone on the talking pair with the keys in the SND and WS-WAIT positions.



(2) At the identifying end B, ground one side of the talking set and run over the wires or binding posts until the pair with tone is located.



(3) At B, after the pair with tone is located, connect the talking set across the pair. This operates the buzzer of the set at A and signals that the pair has been located. At A, shift the keys to the LIS and TLK positions, and remove the connection to the LOW post. The talking circuit must be as shown below:



b. *Working Cable*

In working cables, a talking circuit may be established by one of the following methods, depending on the presence or absence of special circuits.

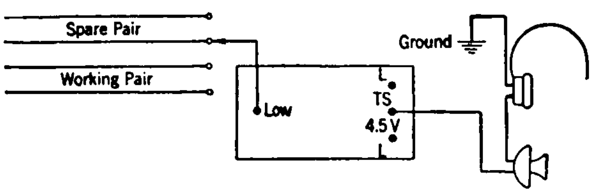
Cable or complement not containing special circuits:

The method described below can be used as follows:

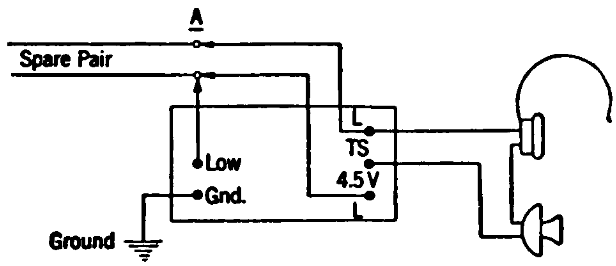
(1) In working cable that does not contain special circuits.

(2) In a complement that does not contain special circuits, provided that the complement can be identified and segregated from the other working complements.

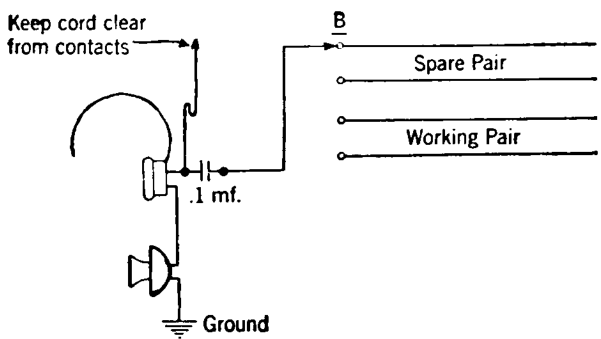
At the sending end A, connect the set as illustrated below and with the keys in the LIS and TLK positions select a spare pair.



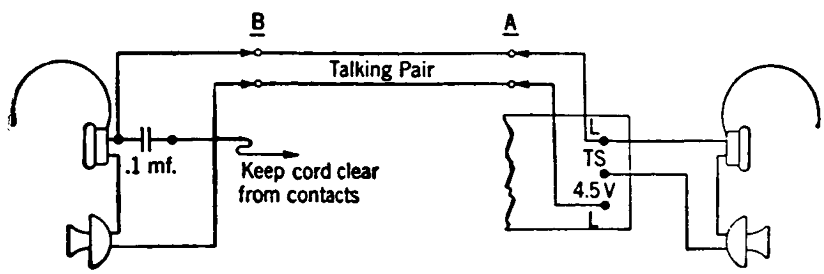
Test the spare pair for defects by means of the battery and receiver tests. Set up the talking circuit at the sending end as shown below and send tone on the talking pair with the keys in the SND and WS-WAIT positions.



At the receiving end B, the talking pair is identified with the talking set connected, as shown below. The talking set must be equipped with a 1/10-mf condenser to avoid interference on working lines.



After the talking pair has been identified, the connections to the talking set at the identifying end B must be rearranged as indicated in the following sketch.



5.3.6 Manhole Maintenance

5.3.6.1. *General*

Most manhole repairs consist of stopping water leaks in the floors or walls of frequently entered manholes, to minimize pumping delays and expense. Depending on the contour of the terrain, the pumping of one manhole may, on occasion, require the removal of water from several adjacent manholes in the run. The volume of water to be handled under such circumstances may make it advisable to exclude water from certain of the manholes.

Water entering through the conduit can usually be stopped by plugging the duct entrances as described in paragraph 2.2.3.4. It may be found, however, that water is also entering around duct entrances, through construction joints, porous sections of concrete, and at other points which require repairing before all water can be excluded. This section outlines methods which can be employed in effecting repairs of this nature.

Upon completion of any work in which patching materials come in direct contact with the hands, wash the hands thoroughly and apply a light coating of vaseline or oil to the skin to counteract the drying action of the materials.

5.3.6.2 *Tools and Materials*

The following tools and materials will be required for the repair of cracks or porous areas in concrete:

a. Cement

b. Plaster sand

c. Waterplug, a quick-setting powdered material.

d. Calcium chloride solution — (Standard Solution). Prepare by dissolving 5 pounds of commercial calcium chloride (chloride of lime) in 1-1/2 gallons of water. Calcium chloride may be obtained in the form of white crystals at hardware or drug stores. It must be kept in an airtight container to prevent absorption of moisture.

e. Strip oakum or lead wool: Used for caulking purposes. Obtainable at hardware stores.

f. Cold chisel: 3/4 inch.

g. Hammer: 1-1/4 pound or any medium-weight hammer.

h. Trowel: Small, triangular mason's trowel.

i. Basin or bowl: For mixing small batches of Waterplug or cement and calcium chloride solution.

j. Wire brush: For removing slime, dirt, grease, etc, from surfaces to be patched.

k. Vaseline or oil: For application to hands after handling cement.

For patching small areas or where the flow of water to be stopped is severe, the use of Waterplug is recommended. For larger areas, quick-setting cement mortar can be used efficiently and economically. Where extensive patching is required, it may be advantageous to use both materials. At no time, however, should the two materials be combined in one mixture.

a. *Waterplug*

Place a small quantity of Waterplug in the mixing pan and add to it sufficient water to form a cake or pat the consistency of putty. If the cake is too wet to handle, add dry Waterplug to bring it to the desired consistency. Stir just enough to have the cake mildly saturated throughout. Depending on the temperature of the mixing water, the material will begin to set in 2 or 3 minutes; consequently, do not mix more than can be applied within that time. Do not use warm water because this will hasten the set and do not attempt to soften Waterplug by adding water to material which has become too stiff to use.

b. *Quick-Setting Cement Mortar*

Quick-setting cement mortar is prepared by mixing portland cement with a solution of calcium chloride. The action of the calcium chloride solution is to accelerate the setting of the cement. The time required for the initial set depends somewhat on the brand of cement used, its freshness, and the strength of the calcium chloride solution. For this reason, it is best to mix one or more trial batches of mortar and observe the handling characteristics of the mix before proceeding to apply it to the surface to be treated. If the mixture as prepared hardens too rapidly to permit it to be applied properly, discard the batch and mix a fresh batch using a portion of the standard calcium chloride solution diluted slightly by the addition of water. If the material sets too slowly for the intended purpose, the difficulty may lie in the cement. If it is certain that the cement being used is fresh, it is advisable to try a different brand.

5.3.6.3 *Patching Procedure*

a. *Plugging Holes*

Holes may be plugged with either Waterplug or quick-setting mortar, although, if water is running from the hole, the use of Waterplug is usually more satisfactory. If water is running from a fairly large hole, apply Waterplug first to the upper portion of the space to be filled, leaving a small opening at the bottom through which water can flow to avoid building up pressure until the Waterplug first applied has set. After a few minutes, mix a small quantity of Waterplug and shape it in the hand in the form of a conical plug. When a sudden warm feeling and dry appearance comes over the plug, apply it to the opening from below. Force the material well into the opening and exert pressure against the plug for a full minute or longer until the flow of water has stopped. After a few minutes, the surface can be smoothed off with a sharp trowel or chisel to conform with the remainder of the seal. When using quick-setting mortar, similar procedures can be followed.

b. *Sealing Large Areas*

If water is entering over quite a large surface, as a honeycombed area, the following method of treatment should be employed:

(1) Provide a weep hole near the center of the area by cutting deeply into the concrete or enlarging a hole which already exists at that point.

(2) Beginning near the outer edge of the area, apply overlapping patches of quick-setting mortar or Waterplug around the area to divert the flow of water toward the center.

(3) Apply successive patches, continually narrowing the limits of flow.

(4) After all but the center weep hole has been sealed and the flow is confined to this point, the patch should be left undisturbed for a few minutes to allow it to attain strength.

(5) When ready to make the final seal, a conical-shaped plug of patching material must be forced into the weep hole and held in place as described under subparagraph a. above.

5.3.6.4 *Corrosion of Cable Racks and Hooks*

Contaminated soil water entering a manhole is occasionally the cause of rapid corrosion of manhole hardware. When this condition exists, an effort must be made to locate the source of pollution and have it diverted to proper channels, if practicable. Sewage, waste from industrial plants, and brackish water in the vicinity of swamps are examples of possible sources of contamination.

If correction by the above means is impracticable, steps must be taken to exclude the water from the manhole. All leaks in the floor and walls and at the conduit entrances must be repaired as indicated in the preceding paragraphs. All ducts should be sealed in accordance with the provisions of paragraph 2.2.3.4.

When neither of the above methods is practicable, consideration should be given to substituing M-type cable racks and hooks for the usual galvanized steel hardware. Attachment of cable racks to the walls should be made with M-type machine bolts. In order to prevent galvanic action between cable sheath and the M-type hardware (copper-nickel alloy), the cable should be separated from contact with the racks and hooks. This can be done by applying a lead-strap, cable tag to the cable at each hook position, with the wide portion of the tag separating the cable from the hook and rack.

5.3.6.5 *Rodding Ducts*

Make certain that the ducts rodded are the ones selected.

If the conduit run is on a grade, the work will be easier if rodding is done downhill. Where the run contains bends, less effort is required if the straight portion of the duct can be rodded first. Quick coupling duct rods can be passed through medium and large radius bends by turning the rods so that the couplings pivot as they move through the bend.

Use an arrowhead or the loop section of a duct grapple as a leader on the first rod and push the rod into the duct. Then screw or attach additional rods to the last one in the duct and push them into the duct. Repeat this operation until the leader appears in the next manhole.

When possible, push the rods from one section to another without disconnecting them. In the case of a long duct section, rods may be pushed into the duct from each end. The first rod entering the duct from one manhole should be equipped with the loop part of the duct grapple and the first rod entering from the other manhole should be equipped with the hook part of the grapple. When the hooks meet and engage the loops, all the rods can be pulled through the duct.

Rodding tools and cleaning tools are illustrated in paragraph 5.4.2.3 of this section.

Duct rods can be used in conduits partially filled with silt or other material. With rodding tools attached to the rods, the obstruction can be removed. A line can then be fished through the conduit and cleaning tools employed to clean the duct. After the conduit section has been rodded, it should be wired. The wire should be fastened to cable-rack supports or pulling-in irons in the manholes until it is required for cable placing.

5.4 TOOLS

5.4.1 Tools Supplied

The tools supplied at each site on the appropriate—283 Outside Plant Facilities Equipment specification are listed in Table III tool index, and additional descriptive information is given on the following page.

TABLE III

TOOL INDEX

Tool Items Supplied on No. 283 Installation Spec	Quantity Supplied at Site Number 2	4	5	6	11	14	Remarks
Batteries, Dry Cell	4	4	4	4		4	KS-6522 (See par 5.4.1.1)
Brush, Carding					1		(See par 5.4.1.2)
Bucket					1		
Chisel, Cold 3/4 inch	1	1	1	1	1	1	
Clip, Test No. 1	3	3	3	3		3	
Copper, Soldering	1	1	1	1	2	1	
Cord, Extension	1	1	1	1	3	1	
Cutter, Cable	1	1	1	1	1	1	(See par 5.4.1.3)
Cutter, Washer (B)			1	1	1	1	
Cylinder, Propane	1	1	1	1		1	(See par 5.4.1.5)
File, Combination	1	1	1	1	4	1	(See par 5.4.1.4)
Flags, Warning	4	4	4	4	4	4	
Flashlight	1	1	1	1	1	1	
Funnel, 6 inches	1	1	1	1	2	1	
Furnace, Propane (B)	1	1	1	1		1	(See par 5.4.1.5)
Glasses, Safety	2	2	2	2	2		
Gloves, Work	2	2	2	2	12	2	
Gauge, Pressure (C)	1	1	1	1	1	1	(See par 5.4.1.6)
Hammer, Riveting, 70Z	1	1	1	1	1	1	
Hose, Pressure, 30 inches	1	1	1	1	1	1	(See par 5.4.1.6)
Ink, Marking	1	1	1	1	2	1	
Jumpers, E/W Clips	2	2	2	2	4	2	Transfer Cables E/W Clips
Kit, First-Aid	1	1	1	1	1	1	
Knife, Chipping	1	1	1	1	2	1	
Knife, Putty	1	1	1	1	1	1	
Mirror, Splicers	1	1	1	1	1	1	
Pad, Stamp	1	1	1	1		1	
Pliers, 6-inch dia					2		

(Cont'd)

TABLE III—TOOL INDEX (Continued)

Tool Items Supplied on No. 283 Installation Spec	*Quantity Supplied at Site Number* 2	4	5	6	11	14	*Remarks*
Pliers, 8-inch	1	1	1	1	2	1	
Rule, 6-feet	2	2	2	2	2	2	
Screw Driver	2	2	2	2	3*	2	1 ea 4 inches, 5 inches—*2 ea 4 inches
Seat, Splicers	2	2	2	2	2	2	(See par 5.4.1.7)
Scissors, Splicers	2	2	2	2	6	2	
Shears, Tabbing	1	4	2	2	1	2	
Slitter, Sheath (B)(C)	2*	2*	2*	2*	5**	2*	*1 ea B & C types **Type C (See par 5.4.1.8)
Snips, Tape-Armor	1	1	1	1	1	1	
Solder, Rosin-Core	1	1	1	1	1	1	
Solder, Aluminum	1	1	1	1		1	
Stamp, Numeral	1	1	1	1	1	1	
Tape, Measuring	1	1	1	1	1	1	
Tool, Valve Repair	1	1	1	1	1	1	
Valve, Pressure	5	5	5	5	20	5	E/W Cap R (See par 5.4.1.6)
Wrench Kit (B)	1	1	1	1	1	1	
Wrench Ratchet (B)	1	1	1	1		1	
Wrench, Regulator (C)	1	1	1	1	1	1	(See par 5.4.1.6)

5.4.1.1 *Batteries—Dry Type*

Figure 5-3 illustrates the dry batteries employed in lights and test equipment used in conjunction with outside plant. The types of batteries and number of each used in the various application are:

76-type test set:	2—KS-6570 2—KS-6571
84A test set:	1—KS-6570
91A test set:	2—KS-14368 1—KS-14773
Flashlights:	2 to 4—KS-6522

5.4.1.2 *Brush—Carding (B)*

This brush is used for cleaning files and light cleaning of cable sheath for soldering. It consists of a wooden handle and backing to which a length of textile carding is attached to form a wire brush.

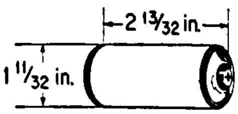
5.4.1.3 *Cutter, Cable*

The wire and cable cutter consists of a steel head having a cutting element, and a lever for operating the lower cutting blade. The bottom of the tool has a tapered socket for mounting the tool on the head section of the small, tree-pruner handle. The operating lever is provided with a pulley at its outer end and an opening spring near the pivot bolt. A chain secured at the bottom of the head and running over the pulley is terminated in a ring to which a 1/4-inch rope may be attached.

The upper cutter blade is in the form of a hook. A notch is provided in the upper part of the hook for engaging and cutting the line wire.

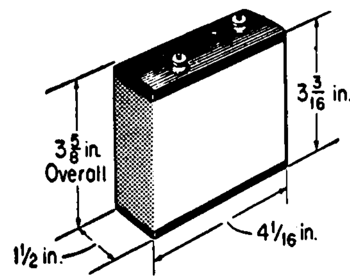
The lower blade which is normally held open by spring pressure, can be locked in a closed position by slipping the pull-chain ring over the shouldered head of the pivot bolt.

KS-6522 Dry Battery



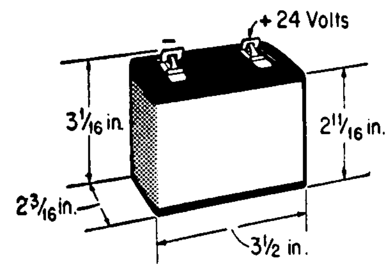
KS 6522 DRY BATTERY
1.5 Volts Weight Approx 0.22 Pound

KS-6570 Dry Battery



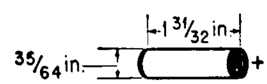
KS 6570 DRY BATTERY
4.5 Volts Weight Approx 0.91 Pound

KS-6571 Dry Battery



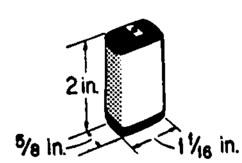
KS 6571 DRY BATTERY
24 Volts Weight Approx 0.94 Pound

KS-14368 Dry Battery



KS 14368 DRY BATTERY
1.5 Volts Weight Approx 0.03 Pound

KS-14773 Dry Battery



KS 14773 DRY BATTERY
22.5 Volts Weight Approx 0.08 Pound

FIGURE 5-3. DRY BATTERIES

The AT-6625 cable cutter cuts cable up to 2-5/8 inches in diameter. It is used for cutting cable at ground level and has tubular-steel handles approximately 2-1/2 feet long. The cutter measures 36-3/4 inches over-all.

5.4.1.5 *Furnace, Propane (B)*

The B-type propane furnace is used in heating, soldering coppers and other materials during splicing operations: Propane gas used as a fuel in the furnace is supplied in steel cylinders containing 20 pounds of propane.

5.4.1.4 *Files*

The size cut and principle use of files available in conjunction with outside plant operations are:

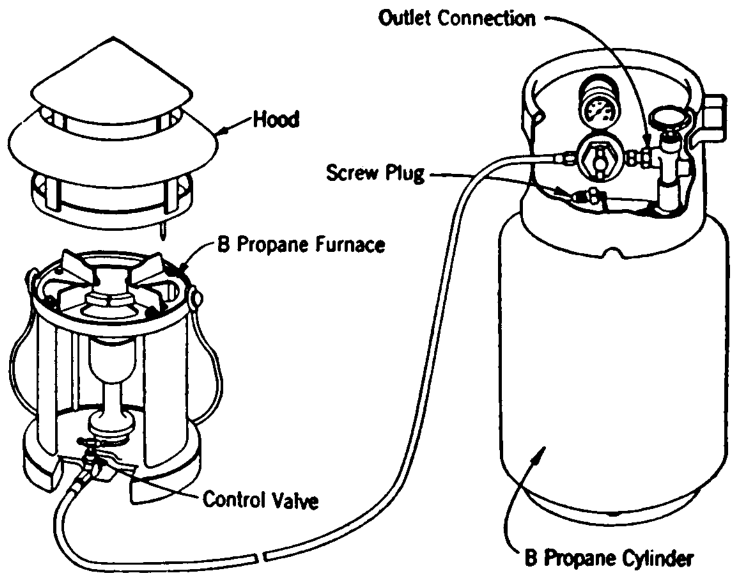
Type	*Size (Inches)*	*Over-all Length (Inches)*	*Weight (Ounces)*	*Cuts*	*Principal Use*
3-1/2-Inch half-round	3-1/2	7-1/4	1/2	No. 0 Swiss Pattern	Wood Bits, Drills
Round	6	9-3/4	1-1/4	Double-Second	Pipe, Porcelain Tubes
Triangular	8	11	4	Double-Second	Strand, Armor
Mill-smooth	8	12-1/4	5	Mill-Smooth	Tools, Station Grounds
Combination*	8	12-1/4	8	Double-Bastard	Soldering Coppers, General
				Single-Smooth	Tools
12-Inch half round	12	16	18	Double-Bastard	Clay Conduit, Building Corners
Lead	10	14-3/8	12	Single-Float	Lead Sleeves, Cable
Hand	10	14-1/4	10	Double-Second	General Construction

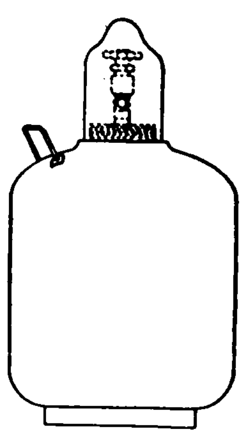
* General use and used in cable maintenance.

In the H files, the handle and file are one piece, the handle being forged integrally with the file. Bastard is coarse cut; second is medium cut; smooth is fine cut.

The furnace is illustrated in the following sketch. It consists of a furnace unit, a 10-foot length of hose with fittings and a high pressure regulator. It weighs about 15 pounds. A 30-foot length of hose and a hood for covering the flame are available as optional parts.

The B-type propane cylinder is a refillable steel container having a capacity of 20 pounds of fuel. It is equipped with a combination shut-off valve and safety release valve that conforms to the Interstate Commerce Commission's requirements. A screw plug is provided for sealing the outlet connection to prevent the escape of gas because of tampering with the hand valve when the regulator is removed. The plug is attached to the cylinder by means of a chain drawn in a noose around the valve.




Approved Type Cylinder

5.4.1.6 *Pressure Testing Equipment*

This equipment includes:

a. Gauge, pressure (C)

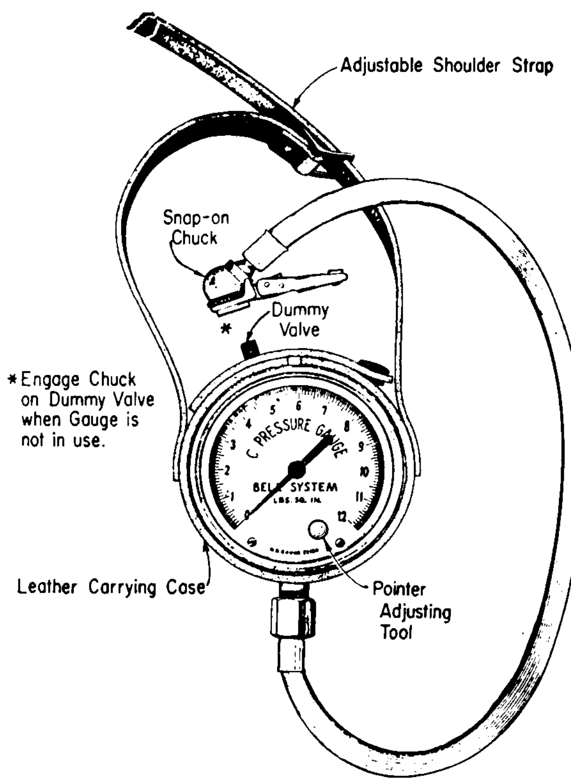
b. Hose, pressure, 30 inches

c. Valve, pressure E/W cap (R)

d. Wrench, regulator (C)

(1) The C-type pressure gauge is shown below. The hose may be removed and the gauge connected directly to the splice case under test as described in paragraph 2.3.3.1.

(2) The 30-inch pressure hose provides hose and fittings for conveying gas from a pressure-testing regulator to a pressure-testing valve. An inner rubber tube is surrounded by a single, impregnated-textile braid and rubber cover. Nominal inside diameter is 3/16 inch and outside diameter is 7/16 inch. One end is equipped with a hose connection gland and nut for attachment to the outlet of the regulator. The other end of B-type hose is equipped with a snap-on chuck; the other end of C-type hose is equipped with a screw-on angle connector.



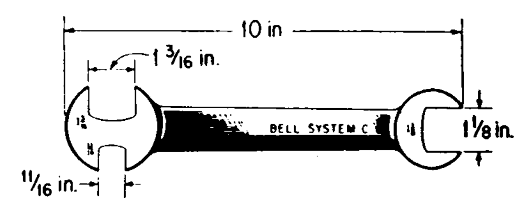
C PRESSURE GAUGE

(3) The pressure-testing valve and cap are used in pressure testing systems to provide pressure measuring and gas admission points in cables and equipment. The valves consist of either a C-, F-, H-, or P-type valve stem equipped with a valve core and are furnished with assembled stems and cores. Valve cores have a stainless-steel spring and are the same kind as used with automobile tire valves; they can be ordered separately for replacement purposes. Valve caps coded M or R must be ordered separately.

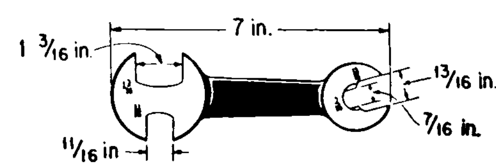
Type Valve	*Description and Use*
C	Designed for soldering directly to cable sheath or sleeve. The lower end is threaded to screw into the opening made by a cable drill. Body is coated with tin or lead-tin solder.
F	Designed primarily for installation in an F-type pressure-testing flange. The lower end is equipped with 1/3-inch pipe thread.
H	Designed for installation in contactor terminal and in terminals. It is equipped with 1/3-inch pipe thread on one end. When installed, it does not project as far from the equipment as would be the case if an F-type valve were used.
P	Designed for insertion into the end of 1/4-inch inside diameter lead pipe or for use in sealing cable ends in the field. One end of this valve is a long smooth cylinder coated with tin or lead-tin solder.

Valve Cap	*Description and Use*
M	Designed for wrench tightening on a valve, where tampering or theft is likely to be encountered. This cap is made of nickel-plated brass with a soft metal gasket and has a hexagonal cross section.
R	Designed for hand tightening on a valve. This cap is made of nickel-plated brass, is dome shaped, and is equipped with a rubber gasket.

e. The C-type regulator wrench is used in pressure-testing work and is shown below.



C REGULATOR WRENCH



B REGULATOR WRENCH

B-Type Regulator Wrench

1-3/16-inch	a.	Cylinder-connection nut of pressure-testing regulator.
	b.	B-type freon adapter.
1-1/8-inch	a.	B-type cylinder connector.
11/16-inch	a.	Hose connection nut.
	b.	B-type gas regulator.

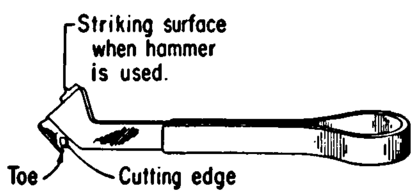
The 13/16-inch and 7/16-inch openings of the B-type regulator wrench were originally provided for use on acetylene-cylinder connections but a special wrench is now furnished with the torch. Both B- and C-type regulator wrenches have openings that can be used on the regulator and hose connections of the B-type propane furnace.

5.4.1.7 *Seat, Splicer's (B)*

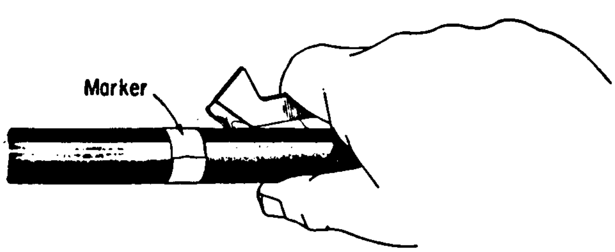
The B-type splicer's seat is intended for use by splicers as a combination seat and tool box. It consists of a wooden box which can be used in three different positions to afford seat heights of 12, 15, and 18 inches. The weight is 15 pounds.

5.4.1.8 *Slitter, Sheath (C)*

The C-type sheath slitter (shown below) is a tool used for removing polyethylene and for cutting tabs on plastic-sheath cables. The C-type sheath slitter has a shaped cutting edge with a smooth rounded toe projecting ahead of the cutting edge. This toe limits the cutting action of the slitter to the polyethylene, by separating the polyethylene from the underlying metal as it is pulled along.



a. After marking the sheath opening, press the toe firmly into the polyethylene by hand, or tap the striking surface lightly with a hammer until the polyethylene has been penetrated.



b. When the polyethylene has been penetrated, level the toe so that it is riding between the polyethylene and the underlying metal, and lifting the polyethylene away from the metal. Then slit the sheath for the length of the opening, moving the tool along with light taps from a hammer, or pulling it by hand.

5.4.2 Additional Maintenance Tools

In addition to the tools listed in Table III, those listed in Table IV may be required, if sections of cable and splice cases are to be replaced and if manhole and conduit maintenance is anticipated. The use for these tools is also given in Table IV and a further description is given in the paragraphs below.

5.4.2.1 *Bar, Pry (B)*

The pry bar is 12 inches long, weighs 1 pound, and is used for separating the two halves of splice cases. It is furnished with a fulcrum block to facilitate using the pry bar. (See paragraph 5.3.4.1.)

5.4.2.2 *Bar, Tamping*

This bar is used for tamping back fill and weighs 16 pounds. It consists of a solid rod handle terminated at the lower end in a flat-faced, rammer butt.

5.4.2.3 *Duct Rodding Equipment*

The equipment used for rodding and wiring ducts of an underground system are:

a. Wire, fish (B)

b. Rod, duct

c. Tools, rodding

d. Tools, cleaning

These items are illustrated in Figures 5-4 and 5-5 and their use is described in paragraph 5.3.6.4.

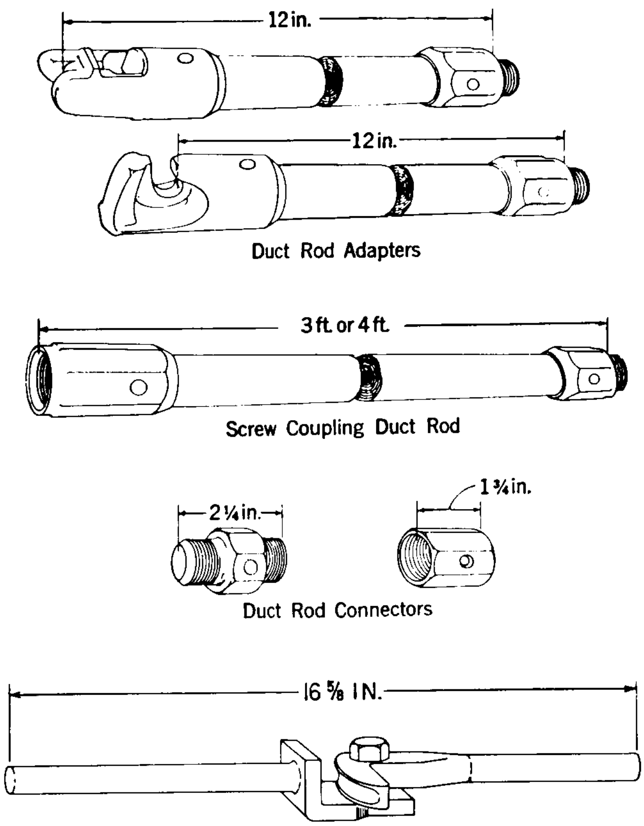
5.4.3 Additional Tools—Canton Island Site Only

Tools, in addition to those listed in Table III, were supplied at the Canton Island site. These tools were supplied for anticipated aerial plant work and are listed in Table V.

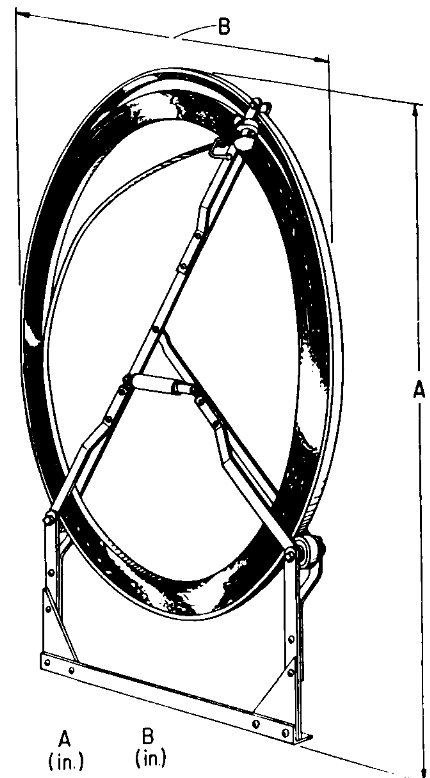
TABLE IV

ADDITIONAL MAINTENANCE TOOLS

Tool	*Use*	*Remarks*
Brush, Wire	Manhole and Conduit Maintenance	
Bar, Pry	Splice Case Removal	(See par 5.4.2.1)
Hammer, 1-1/4 lb	Cable Repair (Splice Cases)	
Hook, Cover, Manhole	Manhole Maintenance	
Handline	Temporary Cable Support	
Rod, Duct	Manhole and Conduit Maintenance	(See par 5.4.2.3)
Screwdriver, 8 inches	Splice Case Work	
Tags, Marking	Cable and Conductor Identification	
Tarpaulin (or Tent)	Cable Repairs	
Tools, Cleaning	Conduit Maintenance	(See par 5.4.2.3)
Tools, Rodding	Conduit Maintenance	(See par 5.4.2.3)
Trowel	Manhole and Conduit Maintenance	
Twine	Temporary Fastenings, Cable	
Tool, 216B	Terminal Connections	
Wire, Fish, (B)	Duct Rodding, Wiring, Duct	(See par 5.4.2.3)
Construction Items		
Bar, Digging and Tamping	Pit and Trench Work	(See par 5.4.2.2.)
Jacks, Cable	Cable Placing	2 ea E/W Axel
Pick, 5 lb	Pit and Trench Work	
Sail (or Power Blower)	Manhole Ventilation	
Shovel, Round-Point	Pit and Trench Work	
Pump	Manhole Work	



DUCT ROD PULLER



Fish Wire Length (Ft)	A (in.)	B (in.)
100 or 200	35	28
300, 400 or 500	40	38

B FISH WIRE

FIGURE 5-4. FISH WIRE, PULLER, AND DUCT-ROD ADAPTERS

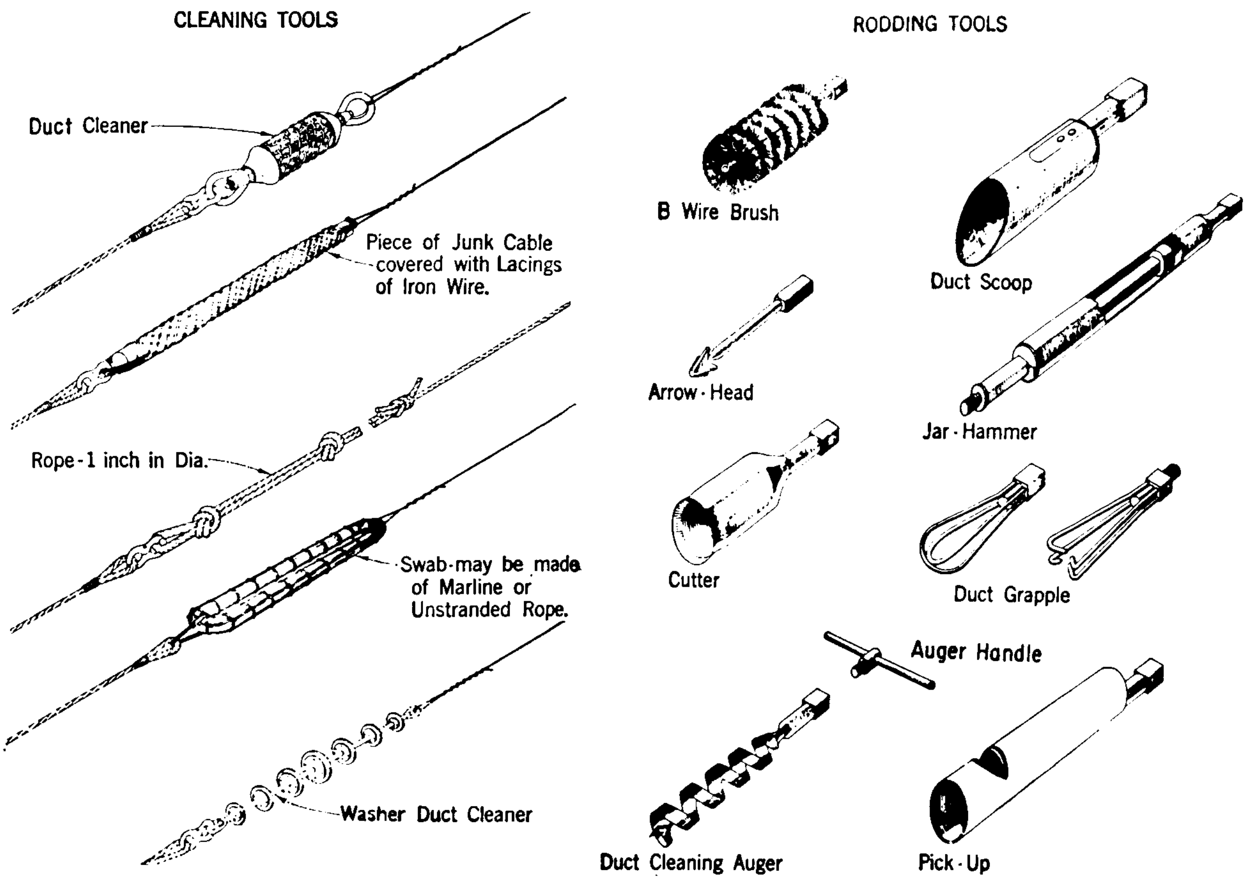


FIGURE 5-5. RODDING AND CLEANING TOOLS

TABLE V

ADDITIONAL TOOLS SUPPLIED AT CANTON ISLAND ONLY

TOOLS	AMT	REMARKS
Belt, Body	1	
Blanket, Rubber	1	42 inches x 72 inches
Brush, Soap	1	
Can, Safety	1	2 Gallons
Car, Cable	1	
Chest, Tool	1	
Climber, Lineman's	2PR	
Copper, Soldering, No. 5	1	Complete (30 x 60) Prestolite Soldering Kit

(Continued)

TABLE V—ADDITIONAL TOOLS SUPPLIED AT CANTON ISLAND ONLY (Continued)

TOOLS	AMT	REMARKS
Cutter, Bolt	1	
Cylinder, Nitrogen (B)	1	
Feeder, Cable	1	
File, Round	1	
Furnace, Kerosene (C)	2	Complete E/W Jet Block and Shield
Goggles	2PR	
Guide, Cable	1	
Hammer, Claw	1	
Holster, C	1	
Hook, Cover, Manhole	1	
Knife, Pocket	1	
Lasher, Cable (D)	1	
Ladder, Extension	1	
Ladder, Manhole	1	
Padlock, Yale	1	
Pouch, Tool	1	
Puller, Slack	1	
Regulator Pressure	1	
Screwdriver, Phillips	1	
Stamp, Steel, Rotary	3	
Strap, Climbers	3	
Strap, Safety	1	
Set, Telephone, 52D	1	
Tool 216B	1	
Wrench, Adjustable	3	1 Ea-8 inches, 10 inches, and 12 inches
Wrench, Lineman's	1	

5.5 TEST EQUIPMENT

5.5.1 Test Equipment Supplied

The test equipment supplied at each site on the appropriate –283 Outside Plant Facilities Equipment specification is listed in Table VI, and additional descriptive information is given below.

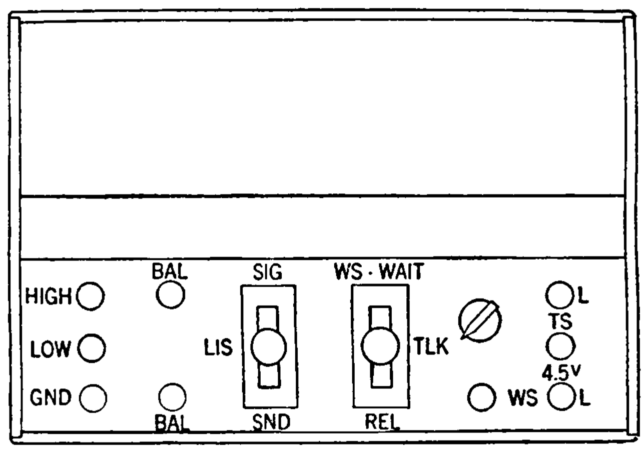
5.5.1.1 *76-Type Test Set*

This set is used for conductor identification, exploring coil tests, and Wheatstone-bridge measurements.

a. *Description*

The 76-type test set is a vacuum tube oscillator producing a tone having a frequency of about 500 cycles with a 7-cycle warble. The resulting tone is easily recognized over noise in cables and is not tiring to listen to in making large-cable transfers. The set is housed in a metal box with a removable hinged cover.

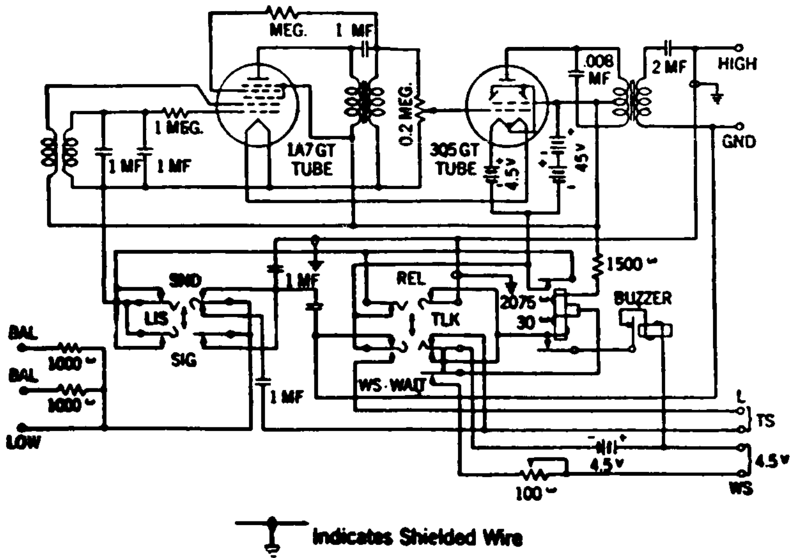
The position and markings of the keys and binding posts in the set are illustrated below.



Abbreviations:

GND—Ground	SND —Send	REL—Relay
BAL—Balance	WS —Wet Section	L —Line
SIG —Signal	WAIT—Wait	TS —Talking Set
LIS —Listen	TLK —Talk	

Circuit Diagram: The following is a schematic circuit diagram of the 76-type test set.



Tone Output: The set has both LOW and HIGH tone outputs. The LOW tone is used for identifying exchange cable pairs, in which operation the tone is applied from one conductor to ground. The HIGH tone is used in identifying conductors in toll or exchange cable, when tone is applied between two wires of a pair or quad.

b. *Maintenance*

The 76-type test set is of sturdy construction and should require relatively little maintenance aside from battery and vacuum tube replacements and an occasional check to ensure that the control relay is operating satisfactorily.

Operating tests: Since the 500-cycle tone delivered by the 76-type test set is produced by a vacuum-tube oscillator, there is no sound audible when the set is in operation. However, the operation of the tone generator can be checked by connecting a talking set to the binding posts marked LOW and GND, the keys being set at LIS and TLK. Then turn the tone on and off by moving the tone key slowly from LIS to SND several times. Warble tone must be heard each time the key is at SND.

If the operation of the tone seems to be erratic, it indicates that the batteries are low or that one of the vacuum tubes is defective. If no tone is heard, either the batteries are low or connected incorrectly, or one of the tubes has failed.

If steady tone is heard instead of a warble tone, it is likely that the connections to the filament-battery B1 (KS-6570) are reversed. This must be checked and corrected if necessary.

Batteries: The set makes use of two 4-1/2 volt, KS-6570 batteries, and two 22-1/2 volt, KS-6571 batteries. For ordinary identification operations, the batteries should be discarded when their voltages (measured while the set is in operation) are found to be below the following values: KS-6570 battery, 3.5 volts; KS-6571 battery, 19 volts. However, when the set is used in running down faults with the exploring coil, the battery voltages should not be allowed to fall below 4 volts and 20 volts, respectively. The life of the batteries with intermittent use of the set as a source of tone is about 100 hours of operation, but when the relay or buzzer is being used, the life of the batteries is somewhat shorter.

If the batteries must be replaced on short notice and the above type standard batteries are not available, commercial batteries of corresponding voltage may be employed. Where obtainable, the Eveready No. 714, 4-1/2 volts and Eveready No. 763, 22-1/2 volts must be used, because they will fit into the battery compartment.

Vacuum tubes: If a vacuum tube is defective, it should be replaced using a tube having the same designation. These are commercially available and when replacements must be made on short notice in the field, they can be obtained from a local radio store. Normal replacements must be made in accordance with local routine.

Difficulty has been experienced in obtaining sufficient 1A7-GT and 3Q5-GT vacuum tubes for use in the 76-type test sets. As miniature tubes are more readily available, the 76B test set was redesigned to provide sockets in which the miniature tubes can be used. The modified set has been coded the 76C test set.

The 76C test set is electrically the same as the 76A and 76B test sets and also mechanically, except for the sockets and the tubes. (The 76B test set is similar to the 76A test set except for the type of key employed.) The 76C test set employs a 1R5 tube in place of the 1A7-GT tube, and a 3V4 tube in place of the 3Q5-GT tube.

Orders for tubes for replacement purposes in 76C test sets should specify the 1R5 or 3V4 tube, depending on the type tube required.

Some 76B test sets have been equipped with a 1R5 tube and BA-259863 adapter in place of the 1A7-GT tube. When it becomes necessary to replace a 1R5 tube in one of these 76B test sets, the 1A7-GT tube must be ordered. In this event, the adapter is no longer required.

The Western Electric Company maintains a stock of 1A7-GT and 3Q5-GT tubes to take care of the replacement needs for tubes in 76A and 76B test sets. These tubes, therefore, should be ordered for replacement purposes in the 76A and 76B test sets.

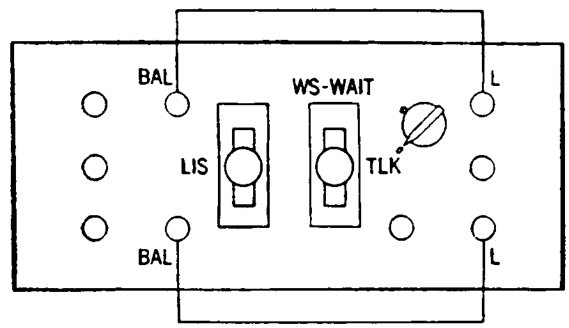
Relay test: The 76-type test set employs a U-6106 relay.

The proper functioning of this relay can be ascertained as follows:

(1) Check the batteries and, if necessary, replace those that have subnormal potential.

(2) Set the keys at LIS and TLK.

(3) Connect a wire from each BAL post to one of the L posts as illustrated below. This will simulate connecting the set to a 2000-ohm line.



(4) Then slowly move the TLK key from TLK to WS-WAIT position several times. The buzzer in the set should operate steadily each time the key is in the WS-WAIT position.

(5) If the buzzer does not operate each time, or if the operation is slow or erratic, the batteries must be checked.

(6) If the batteries are satisfactory, it indicates faulty relay operation. In this event the set should be returned for adjustment in accordance with local routine.

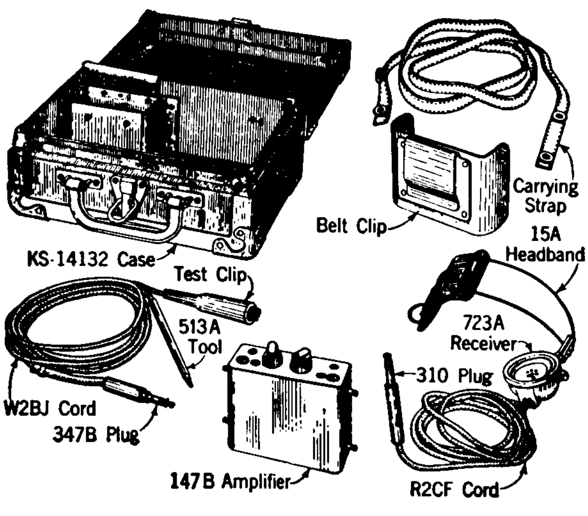
5.5.1.2 *91A Test Set*

This set is used for conductor identification and fault location when an amplifier is required.

a. *Description*

The 91A test set consists of a 147B amplifier, a 723A receiver, a 513A tool (probe), and cords and plugs in a KS-14132 carrying case. The 147B amplifier is intended to facilitate testing apparatus where an amplifier is required. The amplifier with the 513A tool is intended for identifying wires in toll and exchange cables without making metallic contact with the conductors at a splice or sheath opening.

The 147B amplier is a three-tube dry battery operated amplifier. It is 4 inches x 4 inches x 1/2 inch and weighs about 1-1/4 pounds. The circuit diagram is shown in the following sketch. The three stages of amplification are contained in a network, coded the KS-14556 network. The network consists of a ceramic plate approximately 1-1/4 inches x 1-1/8 inches x 1/16 inches thick on which the resistors and conductors are printed and to which the subminiature electron-tube sockets and disc-type capacitors are attached. One CK533AX and two CK534AX (Raytheon) electron tubes are used in the network. The network is indicated by the dotted lines in the circuit diagram.

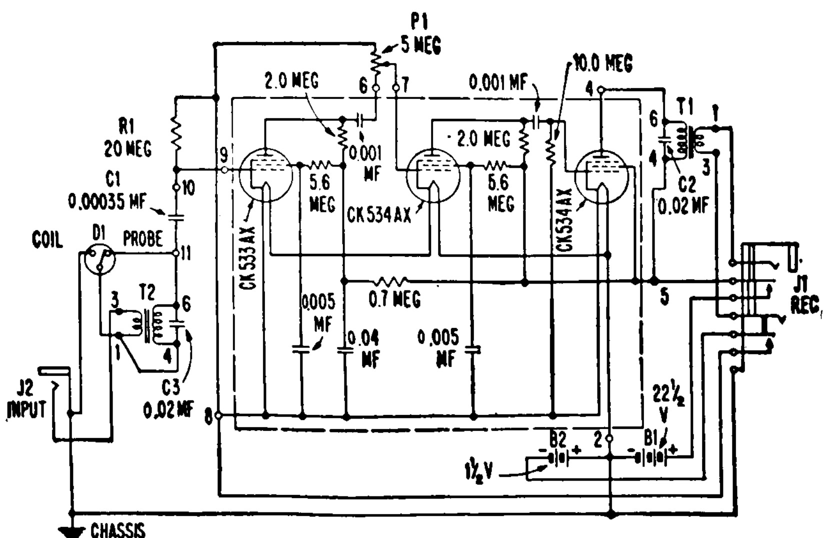


91A Test Set

b. *Maintenance of 147B Amplifier*

Voltage measurements, using a 1000-ohm-per-volt voltmeter, must be made at the network terminals to determine whether it is defective. With the receiver plug in the jack, terminal 8 should measure 1-1/2 volts negative with respect to the chassis (terminal 2); terminals 4 and 5 should measure 22-1/2 volts positive with respect to the chassis. The continuity of the filament circuit between terminals 2 and 8 can be checked with an ohmmeter when the receiver plug is removed from the jack. The resistance should measure between 30 and 65 ohms. The continuity of the wiring can also be tested with the ohmmeter. The low windings of both transformers have a resistance of about 5 ohms; the high windings are about 1200 ohms.

A defective KS-14556 network should be replaced as a unit. For this purpose, the amplifier should be returned in accordance with local routine for making such repairs, or, if authorized, the network can be replaced in the field. To make the replacement, the defective network must be removed by removing the clamp and unsoldering the seven-wire leads from the terminals. The new network must be placed so that the bottom edge is in alignment with the location marks on the terminal strips. Cut the wire leads to the required length and sleeve them with No. 20 varnished tubing. Solder the leads to the same numbered terminals as the



147B AMPLIFIER

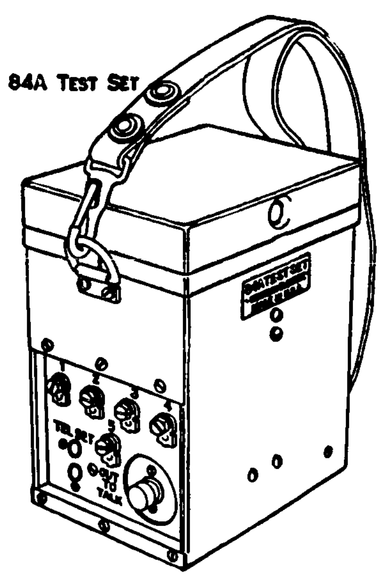
defective network without disturbing other solder connections. Insert the CK533AX tube in the left-hand socket and the two CK534AX tubes in the center and right-hand sockets. The red dot on the tubes must align with the red marking on the sockets. New tubes are equipped with 1-1/2 inch leads; these must be cut to 1/4 inch before the tube is placed in the socket. Then replace the clamp.

5.5.1.3 *84A Test Set*

The 84A test set is a cableman's talking set used when testing or splicing cable. It has both a high-impedance circuit for use on repeatered circuits and a low-impedance circuit for use on nonrepeatered circuits.

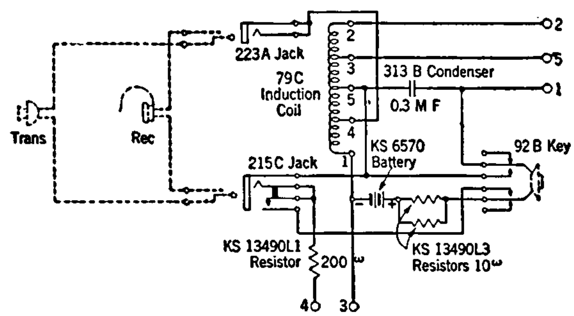
a. *Description*

The 84A test set, illustrated below, is contained in a metal case 6-7/8 inches long, 5 inches wide, and 8-3/8 inches high having a gray-enamel finish. The jacks, key, and binding posts are mounted on an insulating panel accessible at one end of the case. The binding posts are designed to permit firm atachment of test clips. Space is provided in the case for the 63A test set or 52A head telephone set, the test cords, and the KS-6570 battery. The set weighs about 6 pounds exclusive of 63A set and battery. The D161013 and D177679 set are similar in appearance to the 84A test set except that the former sets do not have the No. 5 binding post.



The W2BH cord is provided for connecting the test set to the talking pair. The cord is 6 feet long; one end is equipped with special test clips for making connection to the talking pair, and the other end is equipped with 128-cord tips for making connection to the binding posts on the test set. The W2CN cord is provided for interconnecting the set to an amplifier. This cord is 6 feet long, has No. 27 Universal test clips at one end, and the other end is equipped with a No. 310 plug.

The circuit diagram of the 84A test set is shown below:



b. *Maintenance*

The battery should be replaced when the voltage is less than 3-1/2 volts, with talking set 63A plugged into the jack and the key in the talking position.

5.5.2 Additional Maintenance Test Equipment

In addition to the test equipment listed in Table VI, those listed in Table VII may be required if fault locating and cable-conductor maintenance is anticipated. These items are described in the paragraphs that follow.

5.5.2.1 *(E) Gas Indicator*

The E-type gas indicator is used in testing for the presence of gasoline vapors, natural gas, and other similar combustible gases. The carbon monoxide detector or the carbon monoxide indicator should be used for detecting combustible gases containing carbon monoxide, such as manufactured gas. The carbon monoxide detector can also be used to detect hydrogen sulphide.

This instrument, known commercially as the J-W Sniffer, Model G, is manufactured by Johnson-Williams, Inc.

TABLE VI

TEST EQUIPMENT

Test Equipment Supplied On No. 283 Spec	*Amt*	*Remarks*	*Reference*
76-Type TS (76C)	1	All sites (2, 4, 5, 6, 11, & 14)	
91A TS	1	All sites (2, 4, 5, 6, 11, & 14)	
84A TS	1	Site 11 only (Canton Island)	
1A Toll Test Set	1*	Rack mounted (VF Patch Bay) all sites	ME-621
12B Transmission Measuring Set	1**	All remote sites	ME-621

NOTE

Hewlett-Packard 200CD Oscillators and 400D VTVM will be available at most sites for use on transmission testing of cable pairs. — H/P Equip Manual

* Supplied on—231 Specification (Intercom)

** Supplied on—147 Specification (Test Equipment)

TABLE VII

ADDITIONAL MAINTENANCE TEST EQUIPMENT

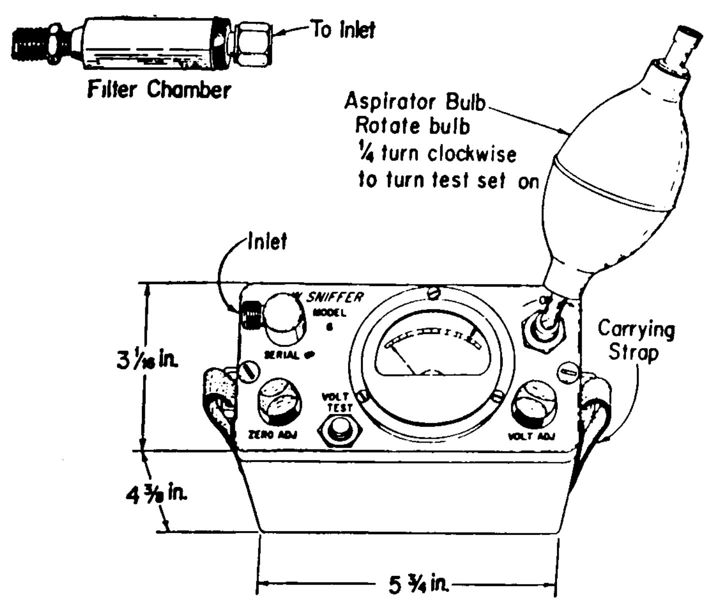
Test Equipment	*Amt*	*Remarks*	*Reference*
Indicator, Gas (E)	1	Bermuda (2) and Canton Island (11) sites	
Voltmeter	1	All sites (2, 4, 5, 6, 11, & 14)	See Note
Megger	1	All sites—Similar to 7679S TS	
Wheatstone Bridge	1	All sites—Similar to KS-14959	
Hand Set, 1011 Type	2	All sites—(2, 4, 5, 6, 11, & 14)	

NOTE

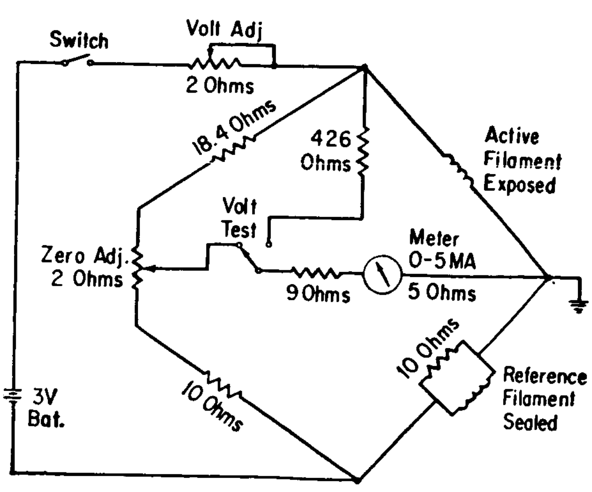
This may be the voltmeter included in the 1A Toll Test Set or the KS-14510-L5 VOM (Portable). The KS meter is described in ME-503, *Teletypewriter and Teletypewriter Test Equipment*, or if a triplett 630 VOM is used, its associated equipment manual should be used for reference.

a. *Description*

The E-type gas indicator is illustrated in the following sketch. It operates on the principle of the Wheatstone bridge. The arms of the bridge consist of an active filament, a reference filament, and two fixed resistors between a rheostat. These elements, together with the indicating meter and eight dry flashlight batteries (KS-14711 dry batteries), are housed in a metal and plastic case. The indicator is equipped with an aspirator bulb, a sampling hose 15 feet long, and a filter chamber. The instrument weighs about 6 pounds.



The wiring diagram of the E-type indicator is shown below:



Filter chamber: The filter chamber, shown in the photograph above, when equipped with a cotton filter, is used to prevent dust, water, etc, from entering the indicator.

When a mixture of air and combustible gas is drawn into the active filament chamber, the hot filament burns the gas, thus raising the temperature of the filament and thereby increasing its electrical resistance. The change in resistance unbalances the bridge, causing current to flow through the meter. The magnitude of current flow is directly proportional to the percentage of combustible gas (up to the lower explosive limit) in the mixture passing through the filament chamber.

Filaments: There is an active and a reference (or inactive) filament in the indicator. The active filament is integral with the flame arrester and in the unit that comes in contact with the sample under test. The reference filament should rarely require replacement, but this may be required after very long service or if the indicator has been dropped or otherwise damaged. The active filament should last many months in normal service. Replacement is indicated when it is no longer possible to bring the needle to zero by turning the zero adjuster (with batteries in good condition). Another indication for replacement of the active filament is when the needle swings violently upscale with the set on or if zero adjustment is impossible.

To replace the filament-flame arrester assembly (active unit), remove the four screws holding the brass plate to the underside of the panel and then remove the filament lead from the subpanel terminal. When placing the new filament-flame arrester assembly, make sure that the gasket is in its proper place. Tighten the four screws evenly. Then replace the lead.

b. *Maintenance*

Dry Batteries: The eight KS-14711 dry batteries are held in the battery holder located in the bottom of the case. To replace the batteries, remove the cover of the instrument and pull the battery holder out. The battery holder removed is shown below. Never remove the holder by pulling on the contacts; if the holder sticks in the case, hold it upside down and tap it gently on a solid surface. After new batteries have been installed, replace the holder. The holder can be replaced in only one position; this eliminates the possibility of replacing the holder incorrectly in the case, resulting in an inoperable indicator. The batteries should be replaced as a group. The batteries are exhausted when the needle cannot be brought up to the arrow on the meter scale.

c. *Replacement Parts*

The following items are available as replacement parts:

(1) Battery, dry, KS-14711

(2) Bulb, aspirator

(3) Chamber, filter

(4) Filament, with flame arrester

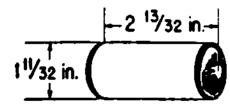
(5) Filter, cotton (package of 24)

(6) Gasket, chamber, filter

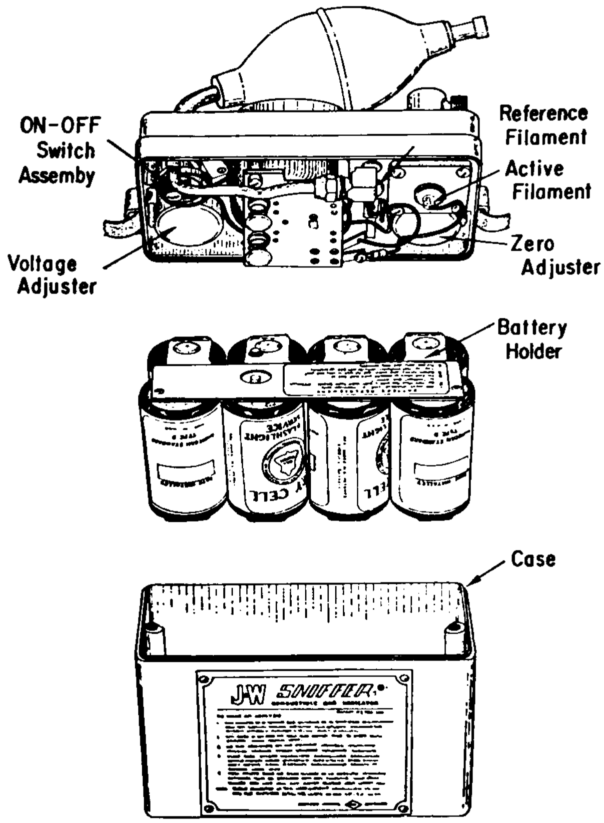
(7) Holder, battery

(8) Hose, 15-foot

(9) Unit, filament, reference



KS 14711 DRY BATTERY
LEAK RESISTANT
1.5 Volts Weight Approx 0.22 Pound

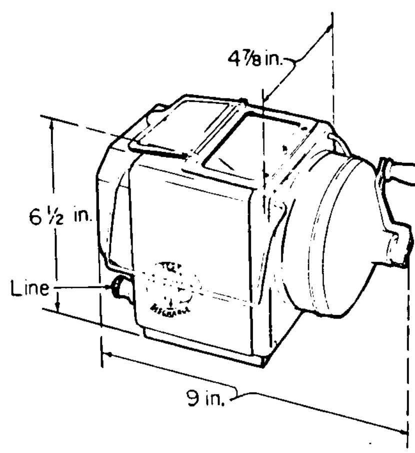


5.5.2.2 *Megger (7679S Test Set)*

The Megger is a true ohmmeter since it measures a very high range of resistance values, regardless of applied voltage. It has a range from 0 to 1000 megohms and an applied voltage of 500 volts dc. The applied voltage will reveal faults that would not be detected with instruments ordinarily applying 3- to 6-volt potentials. This also enables the instrument to measure insulation resistance.

a. *Description*

The Megger 7679S test set is illustrated. It is contained in a black molded case. Earlier models of this set have die-cast aluminum cases. A lid protects the glass cover over the scale. The driving crank does not fold up but its size and shape are such that it is not in the way. The carrying handles are metal and fit together over the instrument or drop down out of the way when the instrument is in use.



This is a direct reading megohmmeter calibrated 0-1000 megohms. The internal, hand-operated, magneto generator provides a 400-volt dc potential. A centrifugal clutch connects the hand crank and the generator. Steady potential is obtained when the crank is turned at or above the slip speed of the clutch. The Megger is equipped with EARTH, LINE, and GUARD terminals and a discharge switch.

WARNING

The insulated connectors of the Megger should be used on high-range tests, and also, if weather conditions make it necessary, when determining insulation resistance. The Megger delivers 400 volts when operated, therefore, the line should be considered hot while being tested.

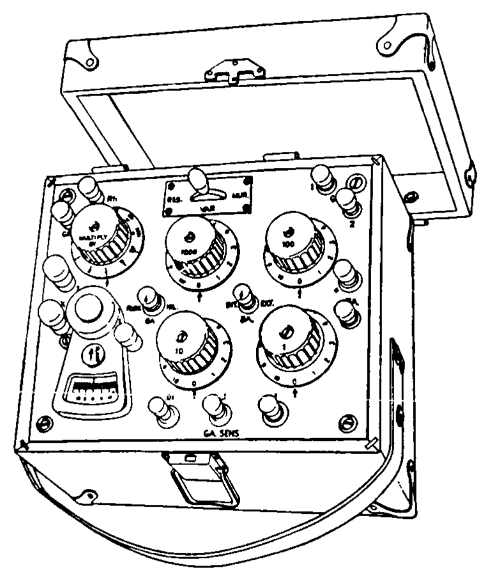
5.5.2.3 *Wheatstone Bridge (KS-1459 Test Set)*

The test set is illustrated below and is used in locating faults in cable conductors by means of bridge measurements.

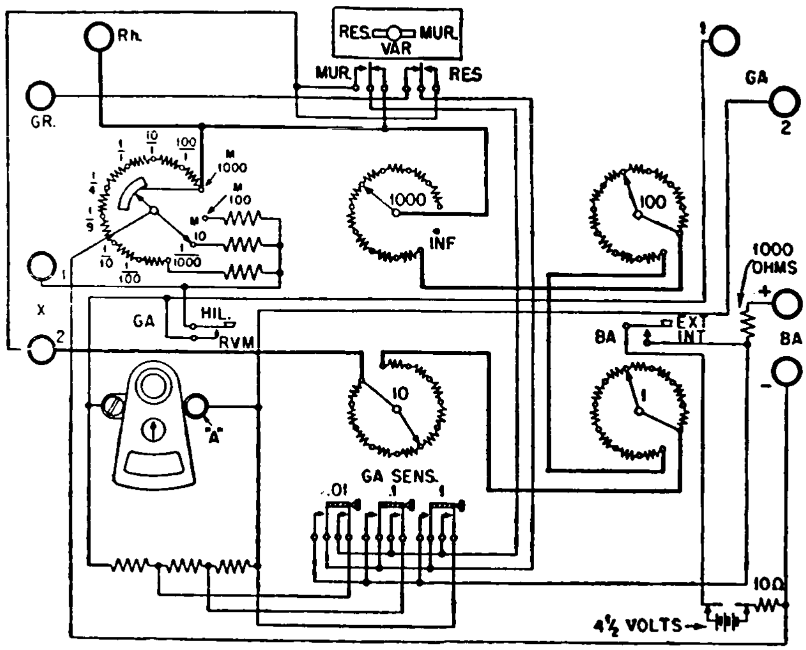
Either the 5430A test set manufactured by Leed and Northrup (L and N) Co or the RN3 test set manufactured by the Industrial Instruments Co may be supplied under the KS-14959 test set designation.

a. *Description*

The L and N 5430A set is illustrated below. The superseded L and N 5430-type set is similar to the 5430A except for the following differences in the faceplates: The galvanometer key is marked IN and OUT instead of RVM and HIL and the battery key is marked IN and OUT instead of INT and EXT. These sets are contained in a wooden case 9-inches long, 7-1/2 inches wide, and 6-1/2-inches high and weigh about 9-1/2 pounds. Three KS-14711 dry batteries are required.



The circuit diagram of the L and N 5430A set is shown below:



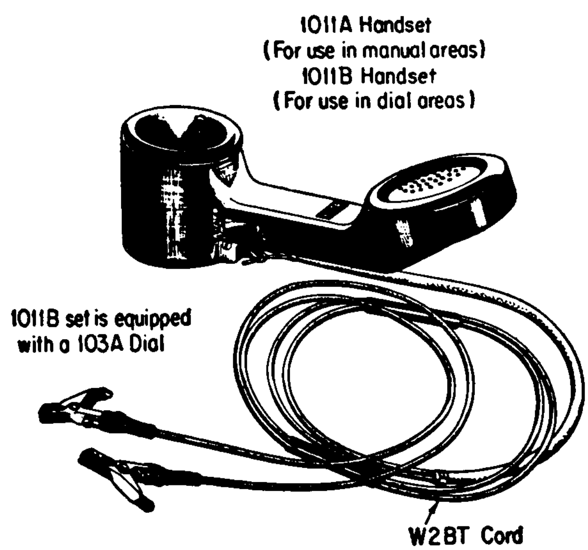
b. *Maintenance*

In general, the set requires little maintenance aside from battery renewals. If the set is not working properly, it must be returned for repair in accordance with local routine.

The battery compartment, on the left-hand side of the case, is covered by a metal panel. To install batteries, remove the panel and worn batteries, then insert the new cells and replace the cover.

5.5.2.4 *1011A Hand Set*

The 1011A hand set, while intended primarily for use by installers and repairmen, may also be used by outside plant forces. The 1011A hand set is intended for use in manual central office areas and the 1011B hand set in dial areas. The set is illustrated in the following sketch. This type set consists of a soft rubber handle containing a transmitter, a receiver, a capacitor, a switch for cutting the capacitor in or out of the circuit for monitoring purposes, and a W2BT cord. In addition, the 1011B set is equipped with a 103 dial. A KS-8402 snap is available for carrying the hand set on a lineman's belt; this item must be ordered separately.



5.6 MATERIAL LISTS

5.6.1 General

Materials required for installation and splicing of outside plant (cables) are listed and described in the paragraphs 1.4, 2.2, and 2.3.

5.6.2 Maintenance Materials

Table VIII compiles the items required for cable replacement or rearrangement, conductor splicing, and manhole and conduit maintenance.

TABLE VIII

MAINTENANCE MATERIAL LIST

Maintenance Material Items (See Note)	*Remarks*	*Paragraph References of This Part*
Bandage, Rubber		
Board, Test	B & C Types	2.3.2.5
Bond, Cable (B)		
Braid, Copper		2.3.4.1
Calcium Chloride Solution	Standard Solution	5.3.6.1
Cement	Manhole Repairs	5.3.6.1
Cement, Type C	E/W Dauber	5.3.2.1
Clamp, Cable	No. 10 and No. 21	1.4.3.3–2.2.1.1
Clamp, Drop-Wire		1.4.3.4–2.2.1.1
Cloth, Wire (B)		2.3.2.2
Cord, Sealing (B)		2.3.2.9
Covers, Splice	C and D Types	2.3.2.1–2.3.2.7
Desiccant (B)		1.4.4.8–2.3.2.2
Duct Seal, Plastic		1.4.4.7–2.2.3.4
Muslin, Rolled		2.3.2.2
Oakum, Strip	Or Lead Wool	5.3.6.1
Paint, Asphalt		2.3.2.2
Rings, Drive, 7/8 inch		2.2.1.3
Sand	Manhole Repairs	5.3.6.1

(Continued)

TABLE VIII—MAINTENANCE MATERIAL LIST (Continued)

Maintenance Material Items (Note)	*Remarks*	*Paragraph References of This Part*
Sign Buried Cable		2.2.3.5–5.3.1.2
Sleeve, Filled (B)		2.3.2.2–2.3.2.5
Sleeve, Tinned-Copper	For No. 10 and No. 14 AWG	1.4.4.4–2.3.2.2
Solution, Pressure Testing	B and C Types	2.3.3.1
Tape, Sealing		1.4.4.6–5.3.4.2
Tape, Miscellaneous	Aluminum	5.3.2.1–5.3.2.2
	DR—(2 inches x 5 feet)	
	Friction	
	Paper	
	Polyethylene	
	Rubber	
	Vinyl	
Thinner		
Tubing, Polyethylene	3-1/2-Inch Lengths	2.3.4.1
Vaseline (Or Oil)	For Hand Protection	5.3.6.1
Washers, Sealing	B and C Types	2.3.2.9
Waterplug		5.3.6.1
Wire, Copper	22 AWG	2.3.2.2
Wire, Bonding	No. 6	2.3.3.0

NOTE

For other material lists, see following paragraphs:

1.4.1	Equipment Items
1.4.4.12	Miscellaneous Splicing Items
2.2.1.3	Miscellaneous Installation Items
2.3.2.2	Splicing Materials

5.7 MAINTENANCE DRAWINGS

5.7.1 General

There are two general classifications of site drawings, job drawing and standard drawings. Job drawings are made for each site. Standard drawings cover units of standard equipment installed at the site. Job drawings include items such as:

a. Drawing Index—000

b. Site Floor Plans—101, —102, —103

c. Wiring Lists—2830

Standard drawings are of the schematic type and are prefixed by SD–.

MG-102, *Plant Operation and Maintenance Procedures,* provides additional information regarding all types of drawings used in conjunction with the Mercury project.

5.7.2 Drawing Number Plan

All job drawings for a particular Mercury site have the same base number. The base number for Canary, for example, is T-6G04. T-6G identifies it as a part of Project Mercury. The last two digits of the base number (04) identify the site.

Following the base number is a dash and 2, 3, or 4 additional digits which indicate the particular type of site drawing.

a. 2 digits—Block diagrams
   Key sheets

b. 3 digits—Drawing Index (–000)
   Floor plans
   Front equipment drawings
   Outside plant facilities
   Cable rack plans

c. 4 digits—Wiring lists

5.7.3 Outside Plant Cable Facilities Drawings

Table IX lists the outside plant, cable facilities drawings, site drawings which show cable terminations and other reference material associated with the cable installation and maintenance.

TABLE IX

DRAWING INDEX

Drawing	Sites: *Bermuda (2)*	*Canary (4)*	*Kano (5)*	*Zanzibar (6)*	*Muchea (8)*	*Woomera (9)*	*Canton (11)*	*Guaymas (14)*	*White Sands (15)*	*Corpus Christi (16)*	*Eglin, Fla. (17)*	*Remarks*
Floor Plan, T&C Bldg	T-6G02-101	T-6G04-101	T-6G05-101	T-6G06-101	T-6G08-101	T-6G09-101	T-6G11-101	T-6G14-101				
Floor Plan, Trans Bldg			T-6G05-102									
Floor Plan				T-6G06-103(1)		T-6G09-103(2)						(1) Pt-to-Pt Rec Bldg (2) FPS-16 Radar Bldg
CDF Layout	T-6G02-140(3)											(3) Control Bldg—Coopers Island
Outside Plant Cable Facilities	T-6G02-360	T-6G04-360	T-6G05-360	T-6G06-360	T-6G08-360	T-6G09-360	T-6G11-360	T-6G14-360	T-6G15-360	T-6G16-360	T-6G17-360	
Outside Plant Cable Facilities	T-6G02-361						T-6G11-361					
Equipment Specification	43002-283	43004-283	43005-283	43006-283	43008-283	43009-283	43023-283	43014-283				
Cable Tray Plan—T&C Bldg		T-6G04-601										
DP11159-1A Toll Test Unit	All Sites											
Test Equipment Manual (TTY)												ME-503
Test Equipment Manual (PBX)												ME-621
Plant O&M Procedures	All Sites											MG-102

PART II

SECTION 1. DESCRIPTION

1.1 GENERAL INFORMATION

This section describes the radio transmission lines used at Kano, Zanzibar, Atlantic Ship, and Indian Ocean Ship Mercury sites for hf radio point-to-point communications system.

1.1.1 Scope of Part II

This part includes component description, test, and maintenance information for the radio transmission lines.

Diagrams showing the radio transmission lines at each of the four sites are included in this section.

1.1.2 System Functions

The radio transmission lines described in this section are used to transmit radio frequency energy between the antennas and the transmitters and the receivers, for the hf radio point-to-point communications system, and the intra-site UHF radio system at Zanzibar.

1.1.3 System Characteristics

The radio transmission lines used in this application of the Mercury project carry energy at various frequencies. Several different values of impedance are used in the system. The transmission lines were chosen to provide correct impedance matching as well as low loss at the operating frequency.

1.2 PHYSICAL DESCRIPTION

1.2.1 Open-Wire Line

The open-wire transmission lines are manufactured by the Wind Turbine Company. They are made in kit form. Model RTL-300 is 500-feet long, with 600 ohms impedance. Model RTL-310 is 100 feet long with 600 ohms impedance. The transmission line consists of two (3-strand, No. 12 AWG high-strength copperweld) wires spaced 12 inches apart, with a characteristic impedance of 600 ohms. The down lead of the antenna constitutes part of the transmission line. The minimum height above ground is 12 feet. Five-inch steel poles set in 5 feet of concrete support the transmission line. A 4-inch x 4-inch x 11-foot wooden crossarm is fastened to a steel bracket atop the pole. The transmission-line wire is fastened to insulators placed in the top of the crossarm. Western Electric drawings DP-10025 and DP-11189 and Burns & Roe's drawings S-4011 and S-4013 give detailed information on the lines and poles.

1.2.2 Coaxial Cable (Solid Dielectric)

Two types of flexible, solid-dielectric coaxial cables are used at these Mercury sites: RG-8A/U and RG-10A/U. These two cables have identical electrical characteristics, but the RG-10A/U cable has an outer armor for added protection. These coaxial cables are shown in Figure 1-1. The properties of the cables are shown in Table I.

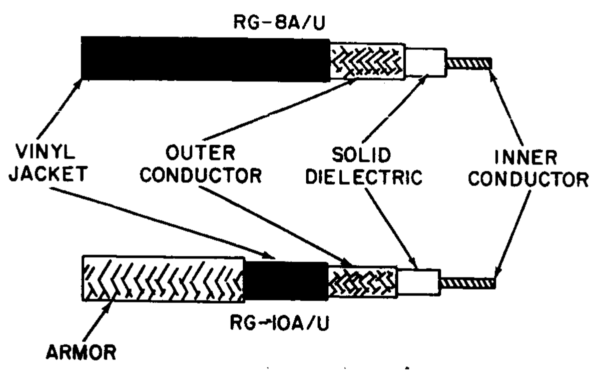


FIGURE 1-1. COAXIAL CABLES

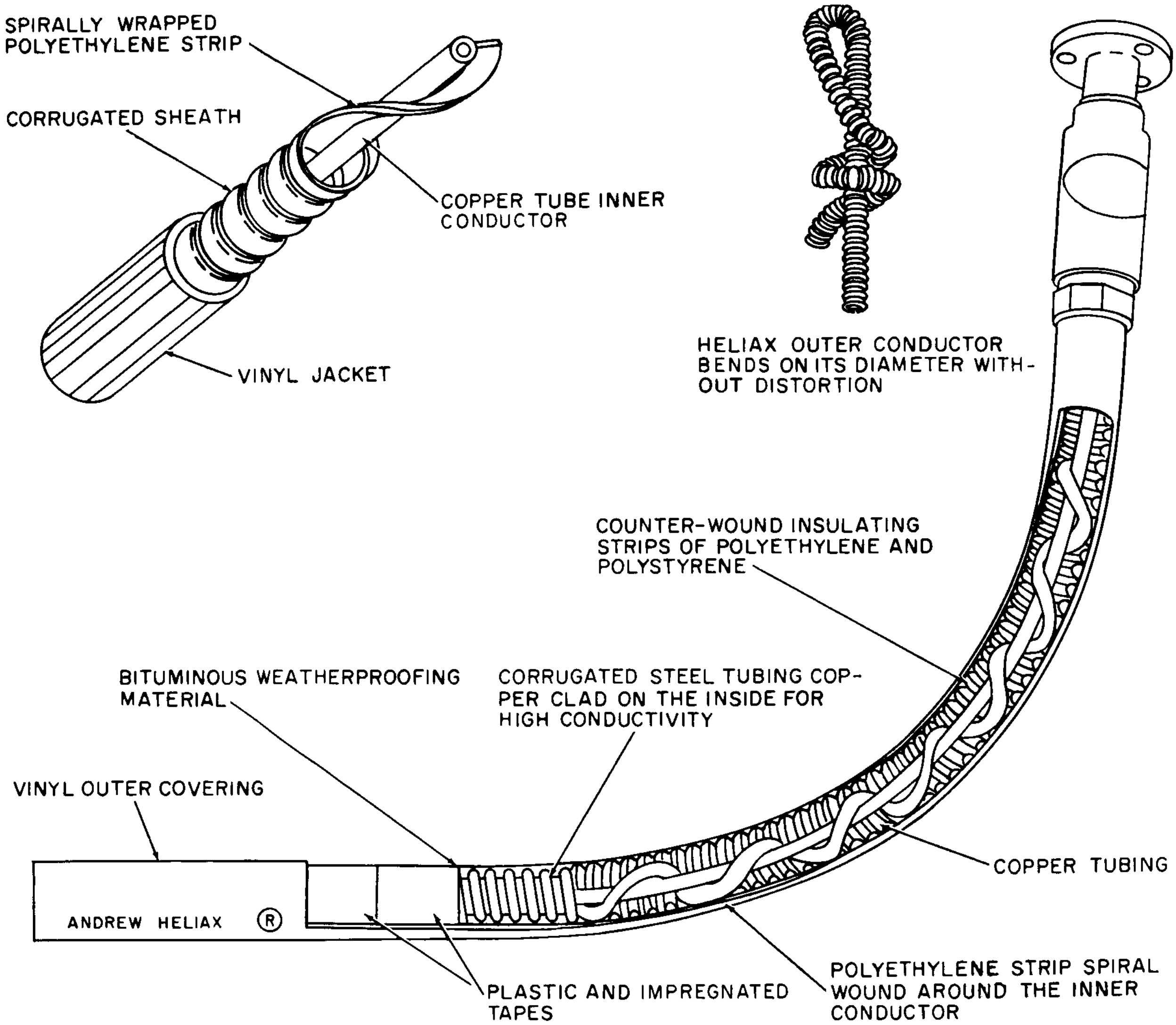


FIGURE 1-2. HELIAX CABLE

TABLE I
PROPERTIES OF COAXIAL CABLES

		RG-8A/U	*RG-10A/U*
Characteristic Impedance, Ohms		52	52
Armor OD		None	0.475
Vinyl	OD Inches	0.405	0.405
Jacket	Color	Black	Gray
Polyethylene Dielectric	OD Inches	0.285	0.285
Outer	Material	Single-Braid Copper	
Conductor	OD Inches	0.340	0.340
Inner	Material	Plain-Copper Strand	
Conductor	Size	7 strands No. 21	
Impedance (Ohms)		52	52
Maximum Volts (RMS)		4000	4000
Capacity MMF/FT		29.5	29.5
Velocity Propagation (per cent of free space vel)		65.9	65.9
Attenuation	4 mc	0.30	0.30
Decibels	8 mc	0.45	0.45
Per	10 mc	0.52	0.52
100 Feet	30 mc	1.00	1.00
	400 mc	4.50	4.50

1.2.3 Heliax Cable

Another type of coaxial cable used at Mercury sites is the heliax-semisolid dielectric cable. Several views of this cable are shown in Figure 1-2. Heliax-coaxial cable consists of a copper-clad, corrugated-steel, outer conductor. The outer surface of the sheath is protected against corrosion by a layer of bituminous material, over which is extruded a vinyl jacket. The copper-tube inner conductor is supported within the sheath by a spirally-wrapped polyethylene strip. Two sizes of this cable are used: 7/8 inches and 1-5/8 inches. Heliax, like all air-dielectric cables, must be maintained under dry pressure to prevent moisture from accumulating inside the cable. Table II gives heliax characteristics.

TABLE II

HELIAX CABLE CHARACTERISTICS

		7/8 inch	1-5/8 inches
Type Number		H 0	H 1
Characteristic Impedance, Ohms		50	50
VSWR, 300-foot length with 50-ohm termination, 0-2500 mc:			
	Average	1.10	1.15
	Maximum	1.06	1.08
Velocity of Propagation, per cent		91.6	91.3
Frequency Range mc		0-5200	0-2800
Insulation		Polyethylene	
Outer Conductor, Jacket OD inches		1.19	2.09
Inner Conductor, OD inches		0.355	0.680
Net Weight, lbs per foot		0.49	1.36
Minimum Bending Radius, inches		10	20
Attenuation	5 mc	0.080	0.042
db per	10 mc	0.120	0.060
100 feet	20 mc	0.175	0.090
	30 mc	0.220	0.115
	400 mc	0.900	0.530

1.3 FUNCTIONAL DESCRIPTION

1.3.1 Open-Wire Line

The open-wire transmission lines are used with the transmitting rhombic antennas at Kano and Zanzibar. These lines connect the rhombic antenna to the exponential line, which is then connected to the coaxitran and then to the coaxial cable to the transmitter. The open-wire lines are shown in Figures 1-3 and 1-4.

1.3.2 Coaxial Cable (Solid Dielectric)

The RG-8A/U coaxial cable is used inside the hf receiver rooms at Kano and Zanzibar. The 7/8-inch heliax (land sites) terminates in a reducer-connector at the top of the receiver bay. A short piece of RG-8A/U cable then connects from this connector to the QDP-38 RF patch assembly at the HF receiver input. The patch cords used with the QDP-38 are also made up of RG-8A/U cable. A short piece of RG-8A/U cable is also used at each end of the 7/8-inch heliax, used for the UHF radio system as shown in paragraph 1.3.3.

The RG-10A/U coaxial cable is used on the Atlantic Ship and Indian Ocean Ship to connect the receiving antennas to the receiver-filter cabinet.

1.3.3 Heliax Cable

The 1-5/8-inch heliax cable is used at Kano and Zanzibar, connecting the hf transmitter coaxial patch panel to the coaxitran which feeds the exponential line to the rhombic antenna. The outside section of this cable is buried approximately 3 feet. This type cable is also used at Zanzibar with the transmitting log periodic antenna. At the ship sites, this type cable is used to connect the filter cabinet to the transmitting antennas. Figures 1-3 and 1-4 show this cable at Kano and Zanzibar. The cable is pressurized at all installations.

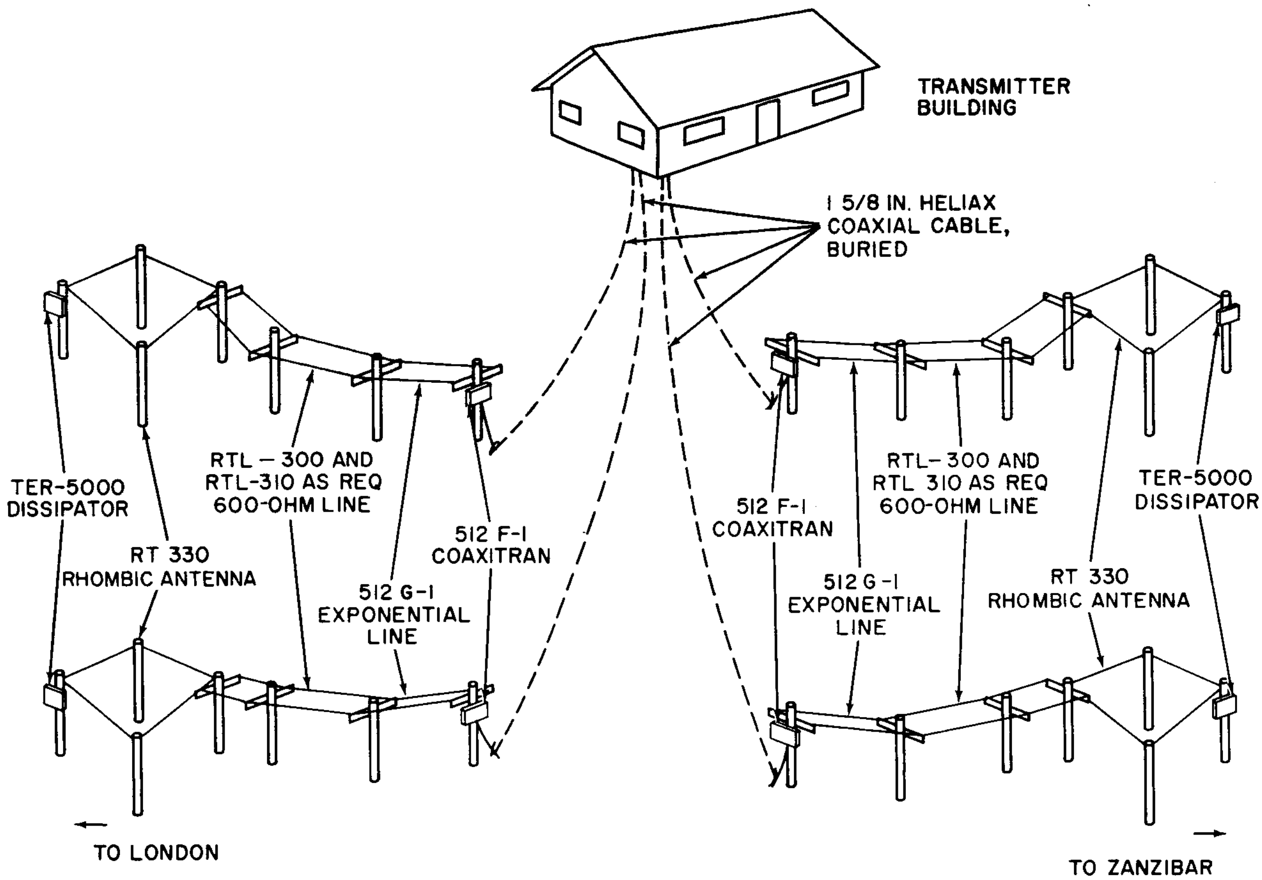


FIGURE 1-3. TRANSMITTER ANTENNA, KANO

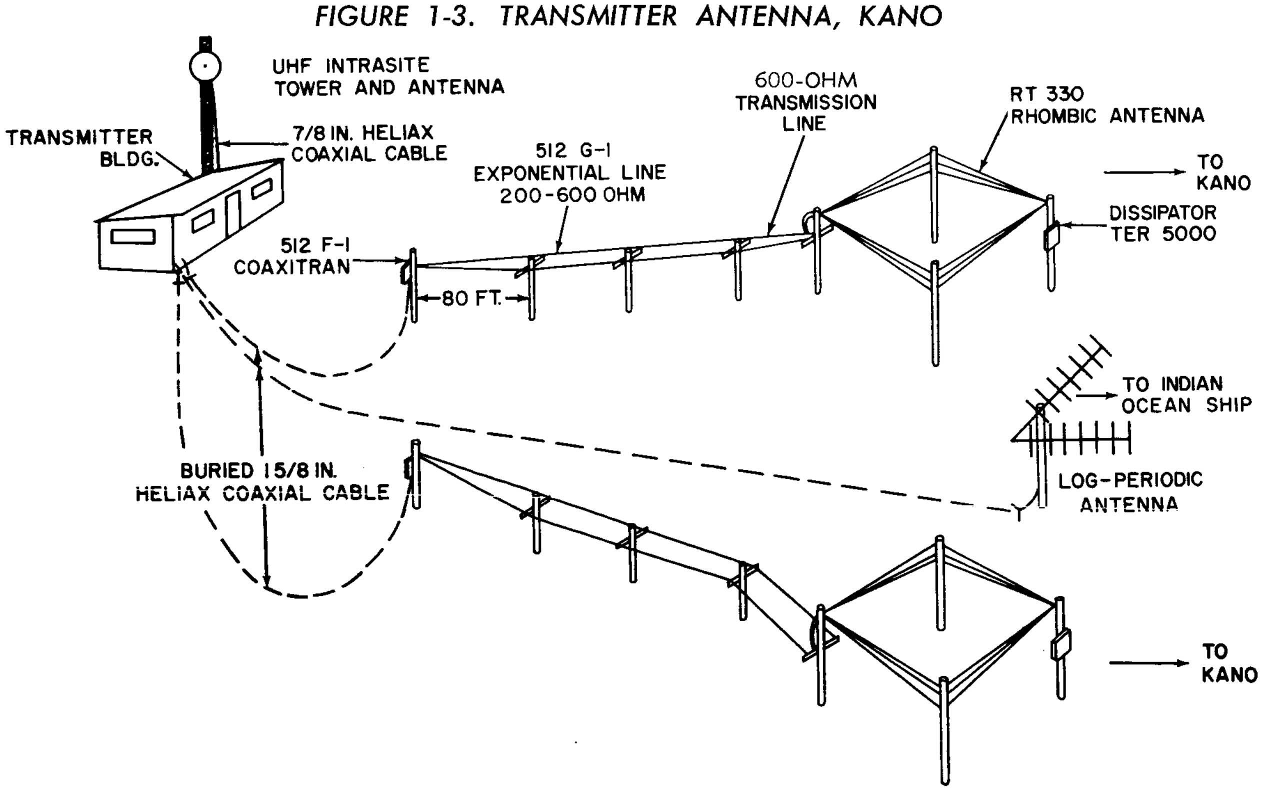


FIGURE 1-4. HF TRANSMITTER AREA, ZANZIBAR

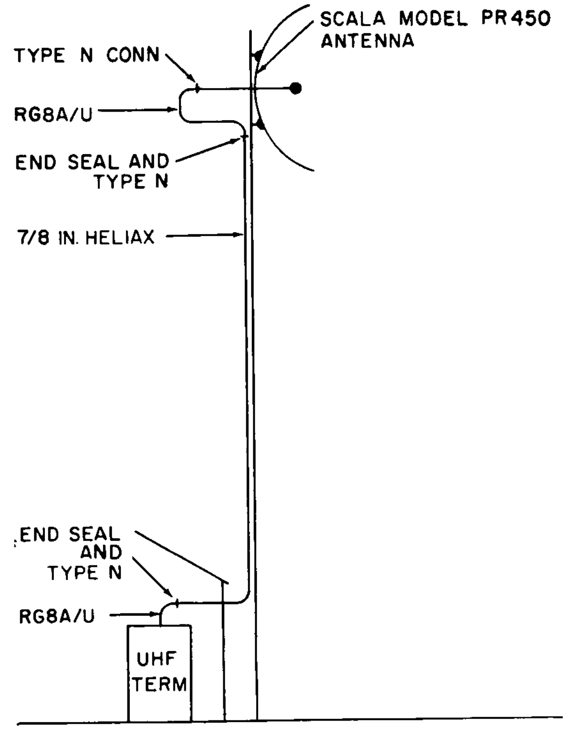


FIGURE 1-5. ZANZIBAR UHF ANTENNA AND TRANSMISSION LINE

The 7/8-inch heliax cable is used at Kano and Zanzibar in the dual-diversity receiving system. It connects the RG-8A/U inside cable mentioned in paragraph 1.3.2 to the balun at the receiving rhombic antenna. Suitable couplings and gas seals are used to join the two different cables together. The entire cable is pressurized. The 7/8-inch heliax cable is also used at the hf receiver and hf-transmitter buildings at Zanzibar to couple the UHF paraflector antenna to the UHF equipment cabinet. See Figure 1-5. Here, suitable couplings and gas seals are also used. The 7/8-inch heliax cable is also used with the receiving log periodic antennas at Zanzibar. Figures 1-6 and 1-7 show the buried 7/8-inch heliax cable at the hf-receiver locations at Kano and Zanzibar.

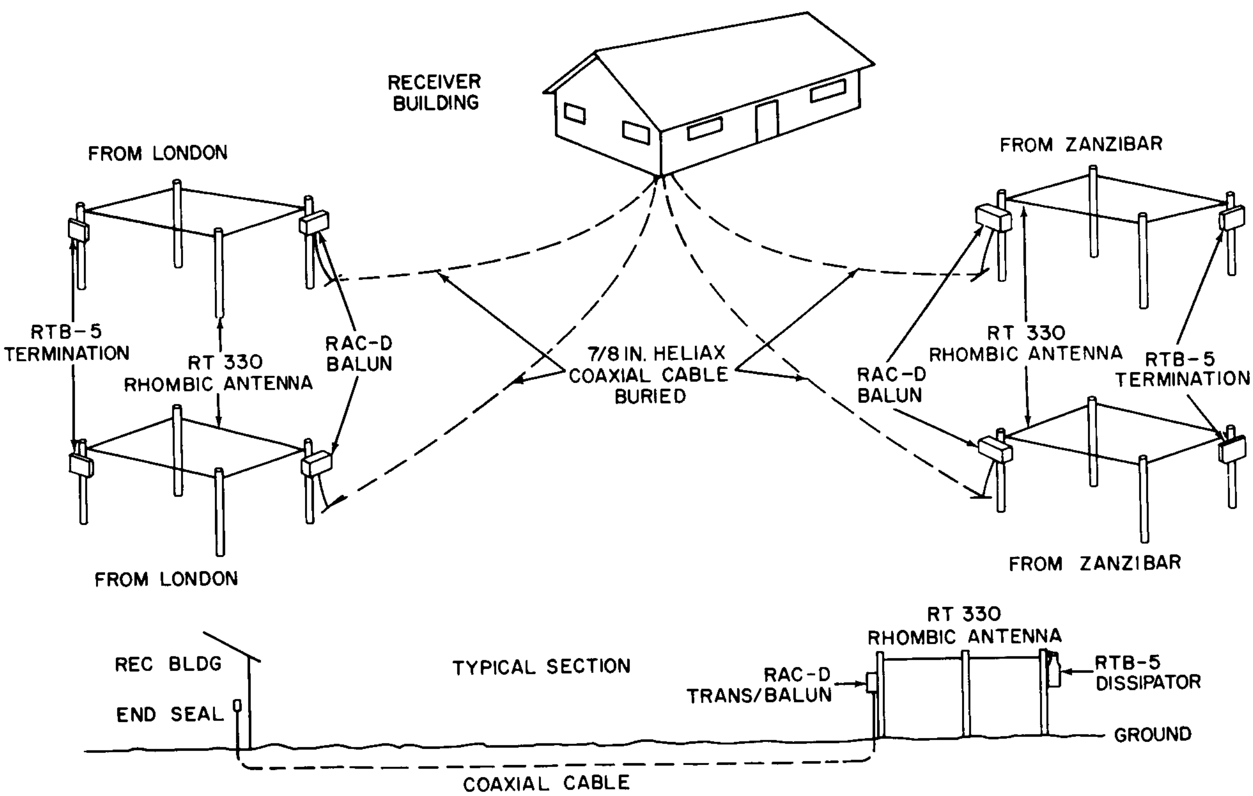


FIGURE 1-6. RECEIVER ANTENNA, KANO

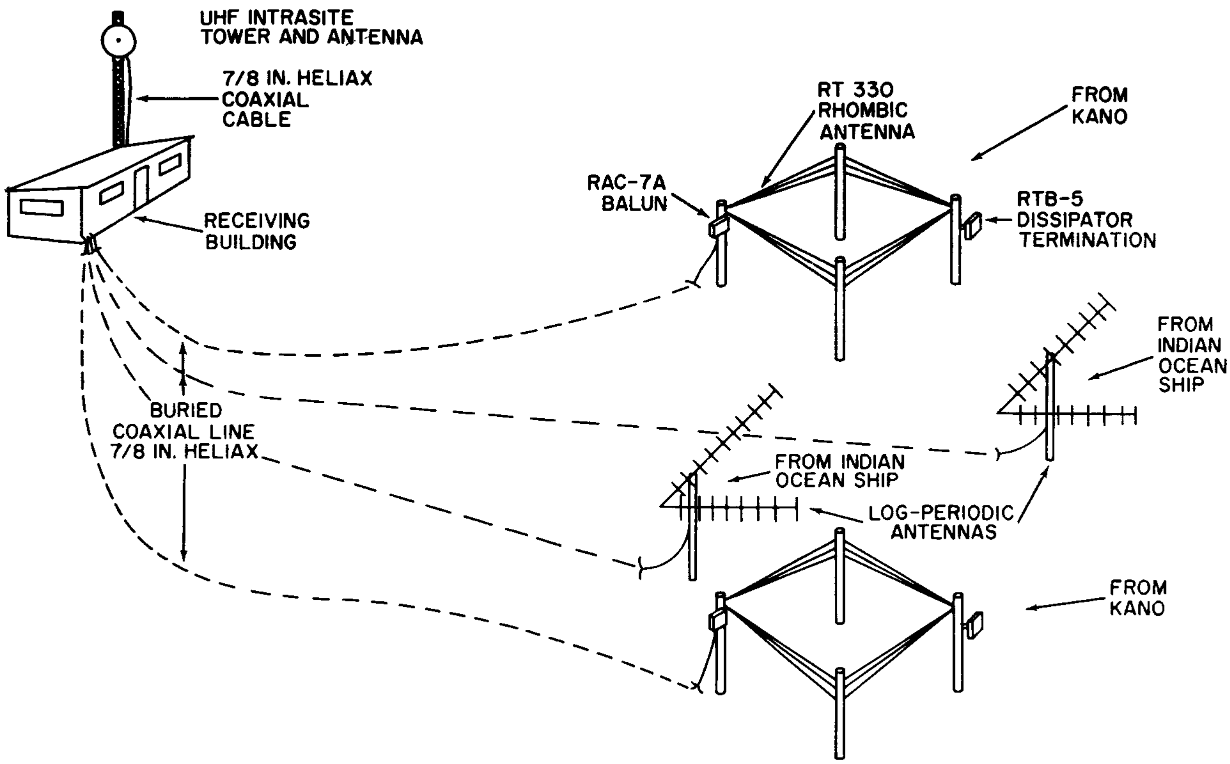


FIGURE 1-7. HF RECEIVING AREA, ZANZIBAR

1.4 EQUIPMENT SUPPLIED, OTHER THAN TRANSMISSION LINES

1.4.1 Index

a. Coaxitran 512F-1

b. Exponential line kit 512G-1

c. Balun, RAC-7A

d. Transmitting coaxial patch panel

e. Dipole-antenna coupler (Balun) DAC-8

f. Shipboard filters, receiving

g. Shipboard filters, transmitting

1.4.2 Description and Use of Coaxitran 512F-1

Coaxitran 512F-1 is an impedance-changing transformer with a 50-ohm unbalanced input and a 200-ohm balanced output. See Figure 1-8. The unit is enclosed in a weather-proof aluminum cabinet for outdoor installation and is 37-inches high, 24-inches wide, and 16-inches deep. The 50-ohm terminal is a rigid coaxial fitting, located on the bottom of the cabinet. The 200-ohm terminal is two insulated 1/4-20 studs located on the upper-left side. The front cover is removable for inspection. Figure 1-9 shows the mounting dimensions of the cabinet.

The parts list is given in Table III.

1.4.3 Description and Use of Exponential Line Kit 512G-1

Exponential Line Kit 512G-1 includes the pre-cut conductors, insulators, spacers, and mounting hardware necessary for constructing an 80-foot exponential line with a 200-ohm balanced input and a 600-ohm balanced output.

TABLE III

PARTS LIST, COAXITRAN 512F-1

Item	*Description*	*Collins Part Number*
Coaxitran 512F-1		522 1297 00

INSULATOR, FEEDTHRU: glazed steatite tapered, cylindrical. 0.281-inch ID, 1-3/4-inch OD. 2-25-/32 inch long: Centralab part No. 48-x000 (qty 2).	190 0176 00
INSULATOR FEEDTHRU: glazed steatite, tapered cylindrical. 1-3/4 inch diameter. 1-3/16 inches long: Centralab part No. X-303-3 (qty 2).	190 6920 00
INSULATOR, STANDOFF: glazed-white ceramic cylindrical. 3/4 inch diameter by inches long tapped each end 10-32 by 3/8 inch long: Centralab Division, Globe Union, Inc.	190 0029 00
SPRING GARTER: beryllium-copper wire. 0.025. 96 turns, oblong shape, Collins Radio Company.	544 2389 002

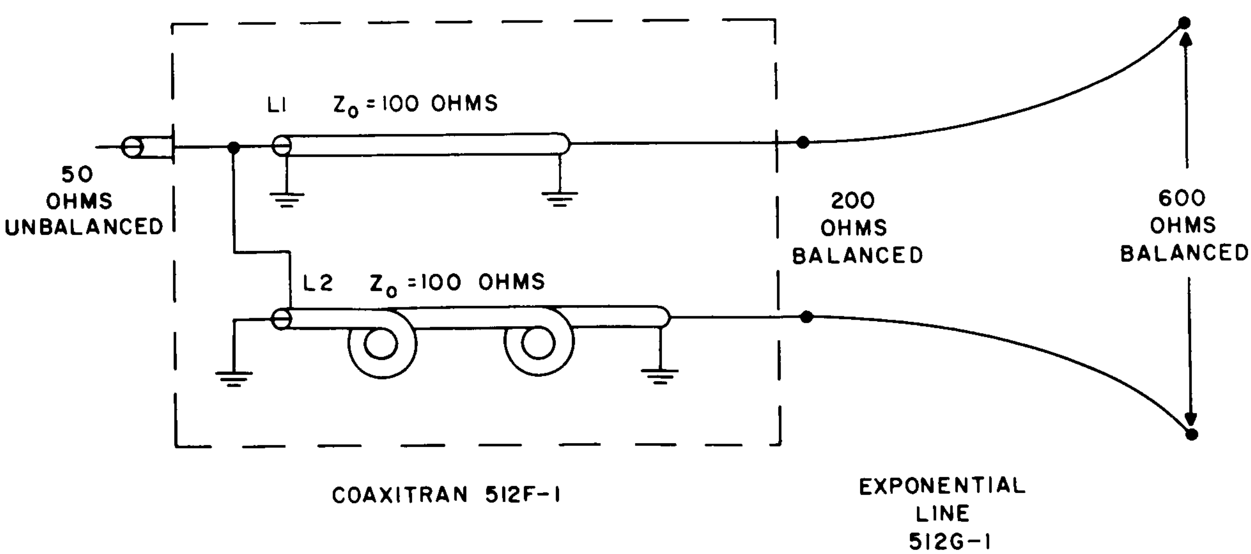


FIGURE 1-8. COAXITRAN 512F-1 AND EXPONENTIAL LINE KIT 512G-1, SCHEMATIC DIAGRAM

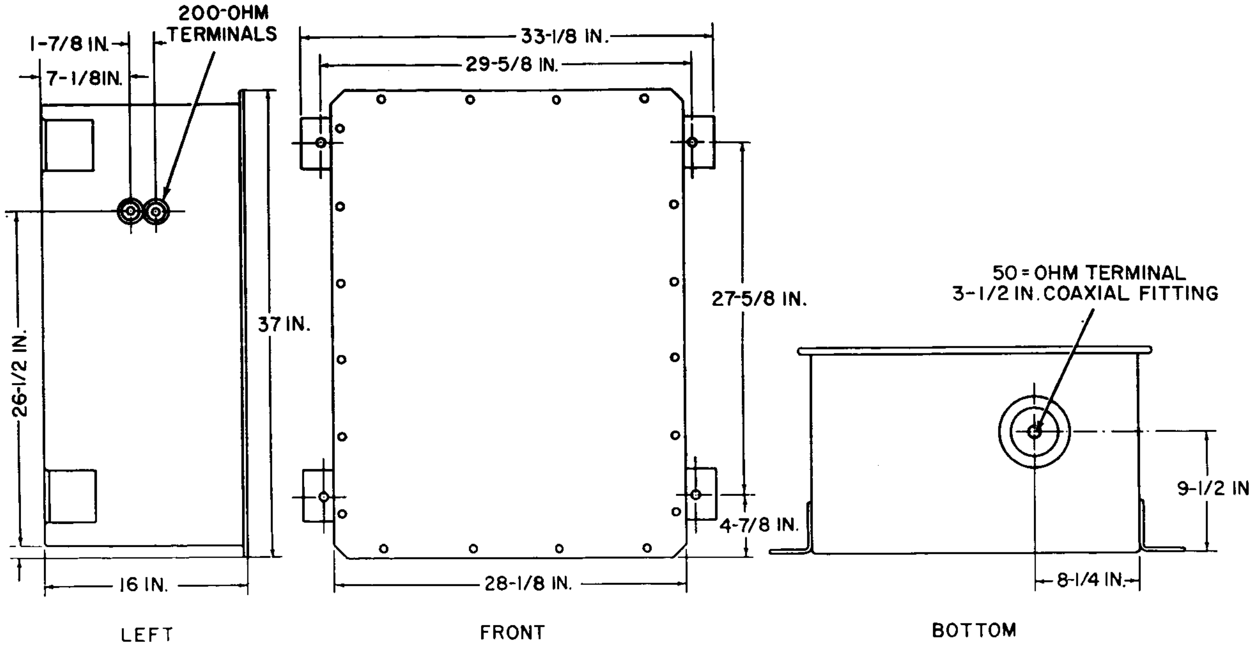


FIGURE 1-9. COAXITRAN 512F-1 OUTLINE AND MOUNTING DIMENSIONS

This kit requires two poles, spaced 81 feet apart with the tops of the poles 12 to 15 feet above the ground. Poles, crossarms, and anchoring hardware are not furnished with the kit. Western Electric drawings DP-10025 and DP-11189 and Burns and Roe drawings S-4011 and S-4013 give detailed information on the lines and poles. Figure 1-10 is an assembly drawing of the exponential line. The parts list is given in Table IV.

1.4.4 Instructions for Coaxitran 512F-1 and Exponential Line Kit 512G-1

1.4.4.1 *General Description*

Together, Coaxitran 512F-1 and Exponential Line Kit 512G-1 form a system for matching 50-ohm unbalanced impedances to 600-ohm balanced impedances in the 4- to 30-mc frequency range. The system is bilateral, and rf power up to 50 kw may be fed through the conversion system in either direction. Coaxitran 512F-1 is an impedance-changing transformer with a 50-ohm unbalanced input and a 200-ohm balanced output. The unit is enclosed in a weather-proof aluminum cabinet for outdoor installation and is 37-inches high, 24-inches wide, and 16-inches deep. The 50-ohm terminal is a 3-1/8-inch rigid coaxial fitting, which is located on the bottom of the cabinet. The 200-ohm terminal is two insulated 1 4-20 studs located on the upper left side. The front cover of the cabinet is removable for inspection. Exponential line kit 512G-1 includes the precut conductors, insulators, spacers, and mounting hardware necessary for constructing an 80-foot exponential line with a 200-ohm balanced input and a 600-ohm balanced output.

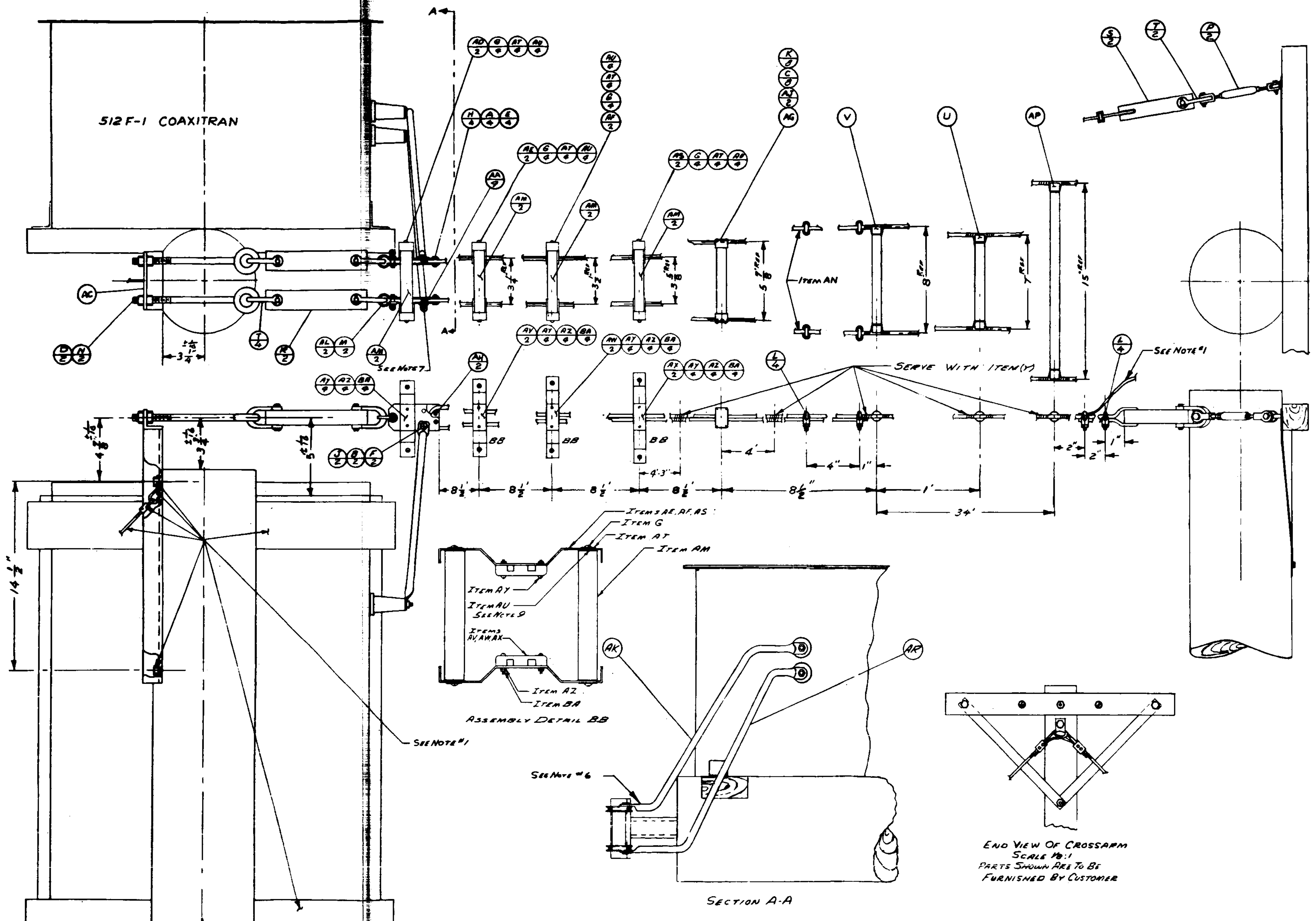
1.4.4.2 *Specifications*

Frequency range	4 to 30 mc
Terminating (or image) impedances	50 ohms unbalanced 600 ohms balanced
512F-1 high impedance fitting	1/4-20 studs on 2 inch centers
512F-1 low impedance fitting	3-1/8-inch rigid coaxial fitting
Power rating	50 kilowatts (with up to 2:1 swr mistermination)
Efficiency of transfer	512F-1: Greater than 99.4% 512G-1: Greater than 98.5%
System standing-wave ratio	Less than 1.5 to 1 at most freq (See Figure 1-11)
Dimensions	512F-1: 37 inches high, 24 inches wide, and 16 inches deep 512G-1: 80 feet long
Weight	512F-1 90 lbs

TABLE IV

PARTS LIST, EXPONENTIAL LINE KIT 512G-1

Item	*Description*	*Collins Part Number*
Line Kit 512G-1		522 1302 004
INSULATOR, SPREADER: glazed steatite, 3/4 inch diameter by 15 inches long over-all; Lapp Radio part No. 26223L-15		190 0174 00
INSULATOR, STANDOFF: ceramic; 1 inch diameter by 6 inches long; each end tapped 1 4-20 5/8 inch deep: American Lava Corp.		190 1178 00
INSULATOR STRAIN: rectangular pillar, 1 inch by 1-1/2 inch by 9-2/3 inch glazed steatite, 1800-lb tensile strength; Lapp Radio part No. 25381-P8		190 0170 00
INSULATOR STRAIN: rectangular pillar, 1 inch by 1-1/2 inch by 10 inch glazed steatite 1800-lb tensile strength; Lapp Radio part No. 25380-P8		190 0171 00
INSULATOR SPREADER: glazed steatite, 3/4 inch diameter by 7 inch long; Lapp Radio part No. 26223L-7		190 0172 00
INSULATOR SPREADER: glazed steatite, 3/4 inch diameter by 8 inches long over-all; Lapp Radio part No. 26223L-8		190 0173 00
INSULATOR STANDOFF: steatite white-glaze 5/8 inch diameter by 5-7/16 inches long; 1/4-20 tap each end; Collins Radio Company		544 4898 002



QUAN. REQ.	ITEM NO.	COLLINS PART NO.	MFG PART NO.	GOV'T PART NO.	PART NAME
4	A	310 3216 00			WASHER-LOCK 1/4 CP STEEL
2	B	310 3224 00			WASHER-LOCK #3/8 CP STEEL
8	C	310 3260 00			WASHER-LOCK #6 CP STEEL
2	D	313 0008 00			NUT-HEX 1/2-20 CP STEEL
4	E	313 0010 00			NUT-HEX 1/4-20 CP STEEL
2	F	313 0129 00			NUT-HEX 3/8-16 CP STEEL
16	G	343 0266 00			SCREW-MACHINE 1/4-20 X 5/8 STEEL
4	H	326 0009 00			SCREW-HEX HD CAP 1/4-20 X 3/4 CP STEEL
2	J	326 0164 00			SCREW-HEX HD CAP 3/8-16 X 5/8 CP STEEL
8	K	343 0497 00			SCREW-6-32 X 1/2 CP STEEL
8	L	015 0788 00	G-450-1/4	Crosby-Laughlin	CLIP-MALLEABLE WIRE ROPE (GALV)
2	M	015 0791 00	G-2096S-209	Fort Wayne	SHACKLE-SCREW-ANCHOR
2	N	330 5500 00	-		EYEBOLT-3/8-13 X 8
2	P	015 0793 00	G-233	Crosby Laughlin	TURNBUCKLE-JAW & JAW 3/8 X 6
2	R	190 0170 00	25381P8	Lapp	INSUL RECT STRAIN
2	S	190 0171 00	25380P8	Insulator	INSUL-RECT STRAIN
6	T	015 0789 00	9035	Company	CLEVIS
1	U	190 0172 00	26223L7	LeRoy, N.Y.	INSULATOR-SPREADER 7"
1	V	190 0173 00	26223L8		INSULATOR-SPREADER 8"
10.0	Y	431 0468 00			WIRE-SOFT ALUM No. 12 (FT)
REF	Z	005 0133 00			VARNISH-BLUE
4	AA	544 4728 002			PLATE-CABLE
SA 1	AC	544 4893 003			CHANNEL-VERTICAL MTG
2	AD	544 4730 002			BRACKET #1
2	AE	544 4731 002			BRACKET #2
2	AF	544 7106 002			BRACKET #3
SA 1	AG	544 4736 002			INSULATOR-STANDOFF, CAPPED
2	AH	544 4737 002			BLOCK-SPACING, CABLE
2	AJ	544 4738 002			COVER-INSULATOR CAP
1	AK	544 4740 003			JUMPER-LOW IMPEDANCE, RIGHT
2	AL	541 6163 002			SPACER
8	AM	190 1178 00			INSULATOR-T1/4-20-C5/8
250	AN	432 1046 00		Rural Light Co	CABLE-5/16, 7 STRAND BARE ALUM (FT)
1	AP	190 0174 00	26223L15	LAPP INSUL. Co	INSULATOR-SPREADER 15"
1	AR	544 4894 003			JUMPER-LOW IMPEDANCE, LEFT
2	AS	544 7107 002			BRACKET #4
16	AT	310 0288 00			WASHER-LOCK 1/4 STEEL
16	AU	302 0094 00			WASHER-CORPRENE
2	AV	544 4733 002			BRACKET-MOUNTING
2	AW	544 4734 002			BRACKET-MOUNTING
2	AX	544 4735 002			BRACKET-MOUNTING
16	AY	343 0191 00			SCREW-MACHINE #8-32-3/4 STEEL
16	AZ	310 0072 00			WASHER-LOCK #8 STEEL
16	BA	313 0046 00			NUT-HEX #8-32 STEEL

NOTES:
1. PARTS INDICATED ARE TO BE FURNISHED BY CUSTOMER.
2. RECOMMENDED THAT 2 X 4'S BE COUNTERBORED TO ALLOW HEADS OF LN. SCREWS TO BE FLUSH WITH SAME.
3. RECOMMENDED HEIGHT OF TAPERED LINE IS ABOUT 12' TO 15' ABOVE GROUND.
4. SPACING BETWEEN CENTERS OF 8 DIAMETER POLES 81 FEET-11/2 INCHES.
5. PACKAGE ALL ITEMS AS LISTED IN BILL OF MATERIAL AS KITS, TO BE ASSEMBLED BY CUSTOMER AT SITE.
6. TIN PLATED TERMINALS OF ITEMS AK & AR TO BE PLACED AGAINST ITEM AB.
7. NUTS ITEM F TO BE LOCATED BETWEEN PLATES ITEMS & AB.
8. LIQUID STAKE ITEM G USING ITEM Z.
9. CORPRENE WASHER ITEM AU IS PLACED BETWEEN BRAKET AND CERAMIC INSULATOR.

FIGURE 1-10. ASSEMBLY DRAWING FOR EXPONENTIAL LINE KIT 512G-1

1.4.4.3 *Installation*

Exponential line kit 512G-1 requires two poles spaced 81 feet apart with the tops of the poles 12 to 15 feet above the ground. Poles, cross-arms, and anchoring hardware are not furnished with the kit. They should be similar to that shown on Figure 1-10. Coaxitran 512F-1 can be mounted to two cross-arms on the pole closest to the transmitter, using the four mounting brackets on the side of the cabinet. See Figure 1-9 for outline and mounting dimensions. The coaxitran 512F-1 must be mounted with the 50-ohm coaxial fitting on the bottom of the cabinet. After the poles are set and the 512F-1 is mounted, assemble the 512G-1 using the Figure 1-10 and the following procedure:

a. Mount the vertical channel (AC on Figure 1-10 and crossarms on the poles as shown.

b. Assemble eyebolts (N), clevises (T), strain insulators (R), plates (AA), and insulator (AD). Place No. 4 aluminum cables (AN) around spacer block (AH) at a point 42 feet and 6 inches from the end of each cable, and bolt in place between plates (AA). Fold cables back along themselves, and clamp with cable clamp (L). Mount strain insulators, clevises, and turnbuckles on single ends of cables.

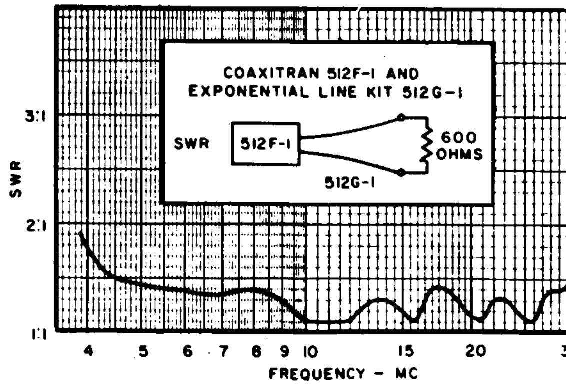


FIGURE 1-11. TYPICAL STANDING-WAVE RATIO VS FREQUENCY CURVE

c. Suspend cables between poles with enough tension to allow 3 or 4 inches of sag between poles. At this point, care must be taken to ensure a uniform taper between the upper and lower cables where they are doubled back in each line. If they are not even, loosen the nuts that hold the spacer (AH) in place, and slide the cable around the spacer so as to even the tension on the upper and lower part of the line and give a uniform taper.

d. Adjust turnbuckles so that each side of the line has the same tension or sag.

e. Mount spacer assemblies (AE, AF, AS, AG, V, U, and AP) in their proper positions along the line as shown in Figure 1-10.

f. Mount coaxitran on crossarms of the pole.

g. Attach jumper cables (AK) to exponential line and coaxitran output terminals making sure the zinc coated lugs are attached to the lines. This lug is zinc plated to prevent chemical action between the lug and the aluminum plates (AA). The position of the plates (AA) relative to the coaxitran terminals can be adjusted slightly by means of the eyebolts (N). Spacers (X) and (Z) are used to maintain safe spacing between the jumper cables.

h. The 600-ohm end of the exponential line can be connected to the 600-ohm transmission line by means of the cable clamps (L) if the 600-ohm line is aluminum; however, if the 600-ohm line is copper, special clamps for clamping aluminum to copper should be used to prevent chemical action.

CAUTION

Before applying power, (1) remove the front cover of the coaxitran and check for damaged parts such as ceramic insulators, and (2) check that the system is properly loaded. Operating the coaxitran with an improper termination at high power may damage it.

1.4.4.4 *Principles of Operation*

The rf impedance conversion system consists of two parts, a coaxitran 512F-1 and an exponential line kit 512G-1. See Figure 1-8. Coaxitran 512F-1 is an impedance-changing transformer with an unbalanced input impedance of 50 ohms and a balanced output impedance of 200 ohms. The 50-ohm input of the 512F-1 is achieved by parallel connection of two sections of 100-ohm rigid coaxial line. One of these sections, L2, is connected to cause a phase reversal between its ends by grounding the inner conductor at the 50-ohm input terminal and grounding the outer conductor at the 200-ohm output terminal. This section then serves as a 1:1 voltage ratio phase reversing transformer. The phase inversion section, L2, is wound into an inductance to minimize the shunting current across the 50-ohm terminal. This current corresponds to magnetizing current in transformer theory. In addition to the 180-degree phase shift because of the transformer action, additional phase shift results from finite velocity of the wave along L2 considered as a transmission line. Compensation for this additional phase shift is achieved by feeding the in-phase wave through coaxial section L1, electrically identical in length to L2. The result is a balanced output with 180-degree phase difference between the voltage waves arriving at the output terminals of L1 and L2. Being connected in series, L1 and L2 present a balanced output impedance of 200 ohms.

The 200-ohm balanced output of the 512F-1 is connected to the balanced input of exponential line kit 512G-1. The output of this exponential transmission line matches the balanced 200-ohm output of the coaxitran to a balanced 600-ohm transmission line.

1.4.5 Balun, RAC-7A

The RAC-7A rhombic antenna coupler is a broadband transformer used as an impedance-matching device, coupling the impedance of a receiving-rhombic antenna to an unbalanced transmission line. It is housed in a weather-tight case measuring approximately 9 inches x 9 inches x 5 inches. The coupler is mounted on the rear pole of the receiving-rhombic antenna. They provide protection from static charges and permit DC checking of the continuity of the antenna and transmission line. Figure 1-12 is a photograph of the unit with the cover open.

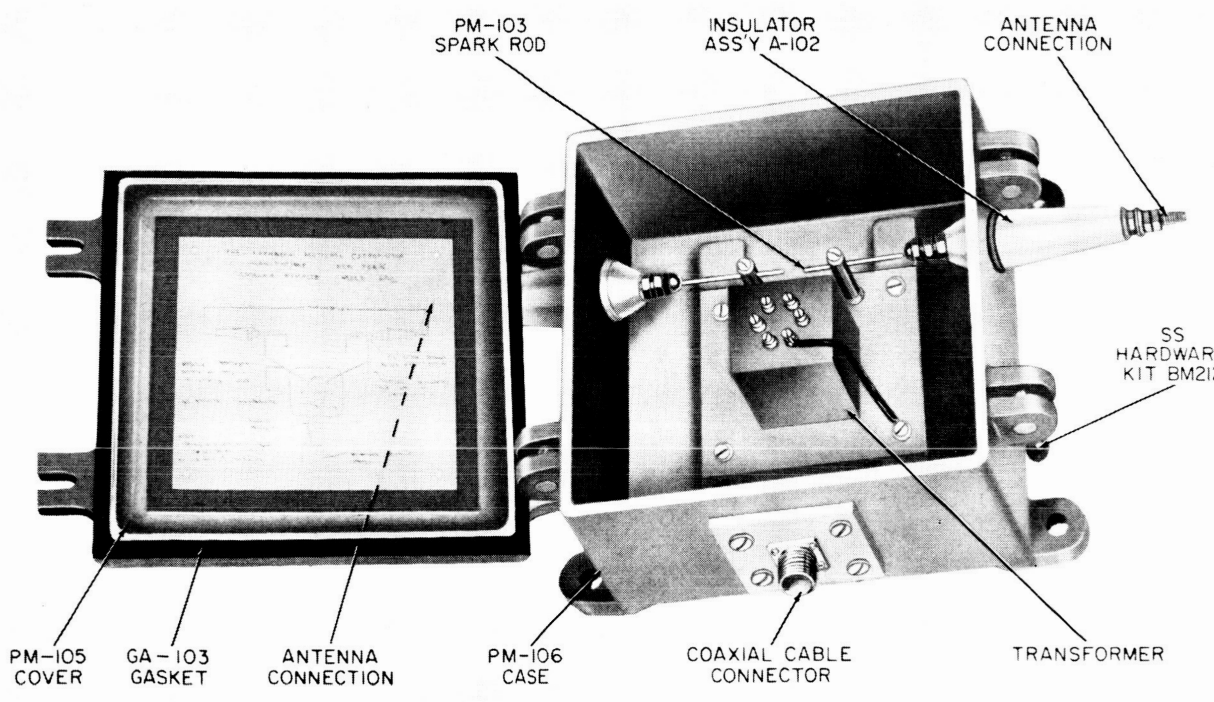


FIGURE 1-12. BALUN RAC-7A

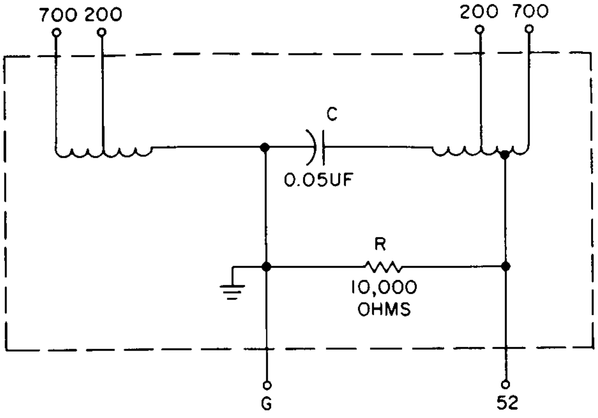


FIGURE 1-13. BALUN RAC-7A SCHEMATIC

Figure 1-13 is a schematic drawing of the coupler which essentially is a broadband auto-transformer. Resistor R of 10,000 ohms across the coaxial cable side has negligible shunting effect. The purpose of this resistor is to allow a leakage path to ground for static charges which may accumulate on the antenna. The reactance of capacitor C over the frequency range is also negligible, acting as a short circuit to radio frequencies. Its purpose is to isolate the windings for dc, to permit resistance measurements of antenna termination. Figure 1-14 shows the installation mounting dimensions.

1.4.6 Transmitting Coaxial-Patch Panel

The hf transmitters, antennas, and dummy load are terminated on the coaxial patch panel. The arrangements of the patch panels for Kano and Zanzibar are shown in Figures 1-15 and 1-16, and for the ships in Figures 1-17 and 1-18. The transmitters are connected to the back of the panel at the T connections. The antennas terminate on the back of the panel at the A connections. The dummy load is connected to A5 at Kano and the ships to A4 at Zanzibar.

To connect a transmitter to an antenna, a patch link, shown in Figure 1-19, is connected from the appropriate T connector to the desired antenna A connector. If the transmitter and antenna connector are too far apart for the patch link to reach, a C channel and two patch links are used. For example, if it is desired to connect antenna 4 to transmitter 1 at Kano, first patch transmitter 1 to channel C2 at the bottom of the panel. The other end of this channel appears near the top of the panel, with a second patch link, from C2 to A4.

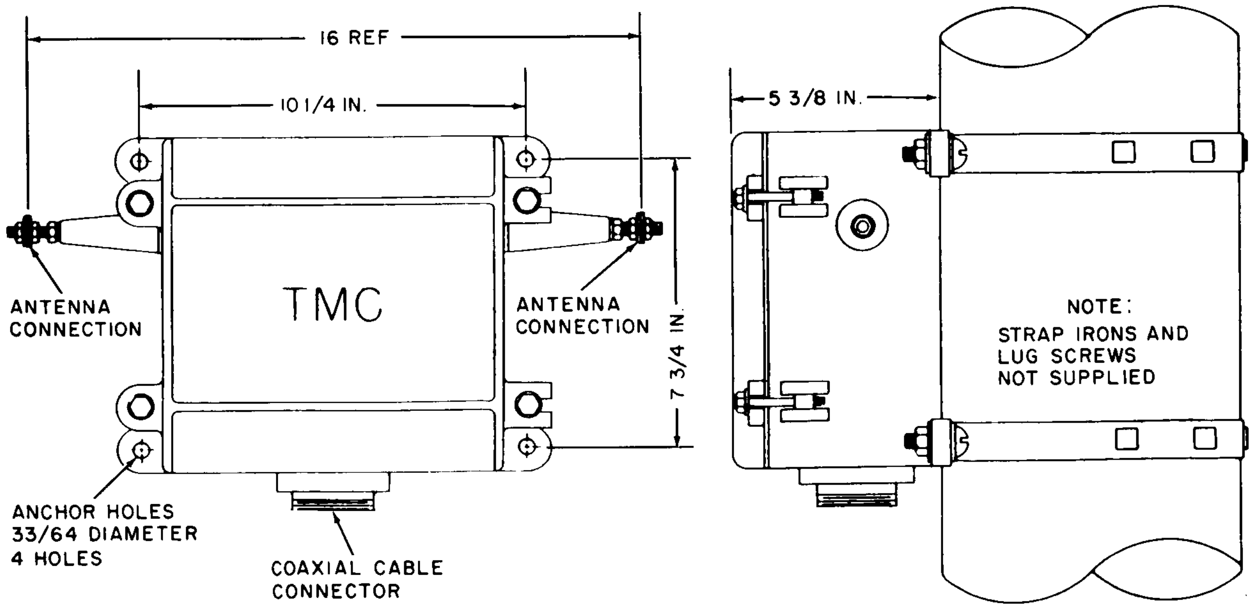


FIGURE 1-14. BALUN RAC-7A, MOUNTING DIMENSIONS

WARNING

OPERATE THE TRANSMITTER HIGH VOLTAGE SWITCH TO OFF BEFORE CHANGING ANTENNAS. WHEN CHANGING THE TRANSMITTER LOAD FROM DUMMY LOAD TO ANTENNA, PUT THE TRANSMITTER IN TUNE CONDITION BECAUSE OF THE DIFFERENCE IN LOAD CHARACTERISTICS. WHEN USING MORE THAN ONE PATCH LINK, ALWAYS CONNECT THE ANTENNA LAST, AND DISCONNECT THE ANTENNA FIRST.

Patching is accomplished by:

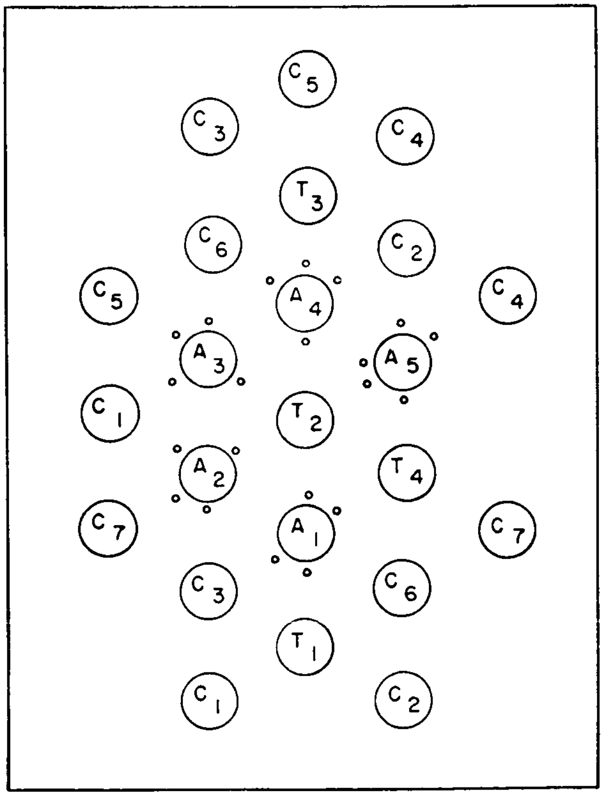
a. Pushing link in place with left hand.

NOTE

Link must be seated fully and actuator on link must line up with panel switch.

b. Pushing the lever arm forward (toward the panel) with right hand. This tightens the clamp. Continue moving the lever arm until the notched bar attached to the connecting arm grips one of the vertical clamp members. The link is now locked in place and the interlock switch is closed.

To release the clamp, pull the spring-loaded notched bar away from the vertical member, and pull the lever arm back (away from the panel) as far as it will go. The link can now be removed from the panel.



TYPE 24497

FIGURE 1-15. COAXIAL PATCH PANEL, KANO

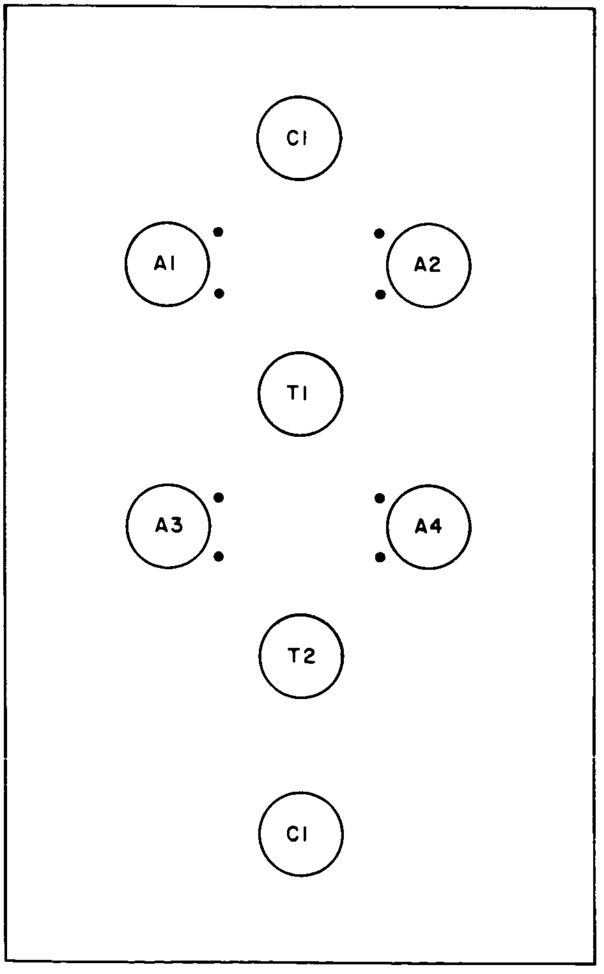
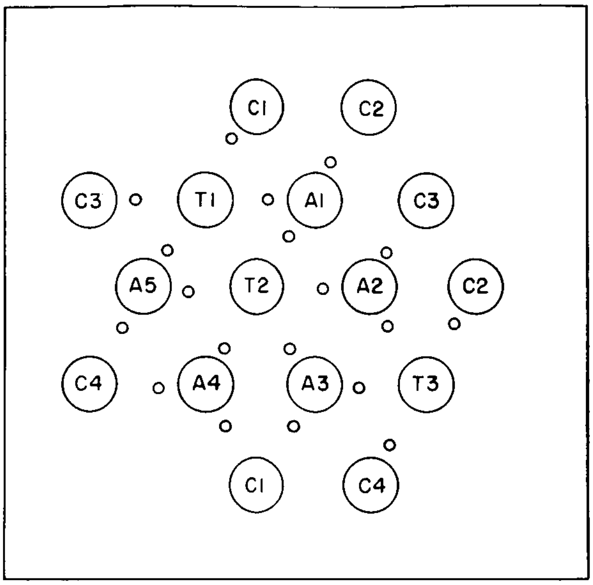
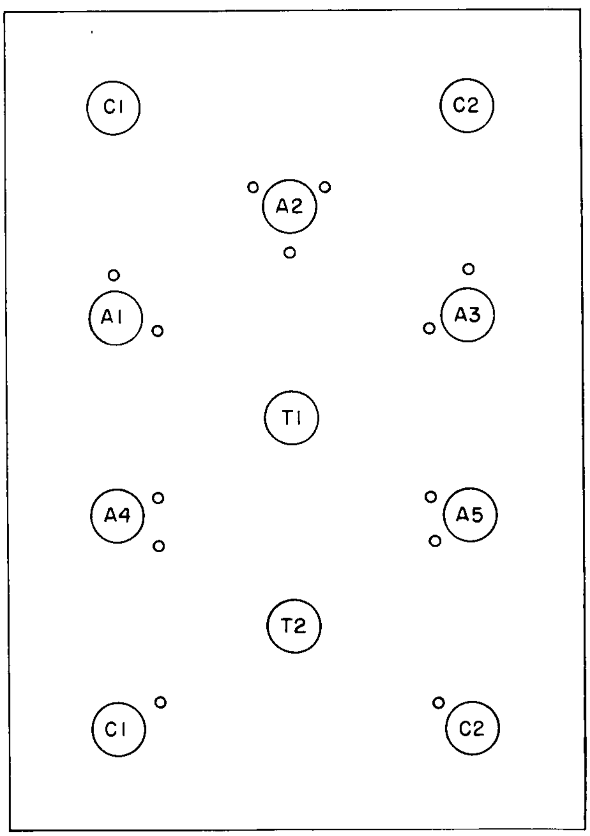


FIGURE 1-16. COAXIAL PATCH PANEL LAYOUT, ZANZIBAR



TYPE 24303

FIGURE 1-17. COAXIAL PATCH PANEL, ATLANTIC SHIP



TYPE 24496

FIGURE 1-18. COAXIAL PATCH PANEL, INDIAN OCEAN SHIP

The dots indicate positioning of microswitches which prevent transmission from an unterminated transmitter. The panel interlock circuit is in series with the transmitter interlock system as shown in Figure 1-20 for Kano. The interlock circuit for the other sites is similar to Kano. Drawing DP-11217 shows the interconnections for the interlock circuit.

This panel is mounted in the upper portion of a 68-inch cabinet.

This cabinet also houses a pressurizing system with an eight-outlet manifold and individual pressure gauges. Provision is made for gas barriers and connection of the transmission lines. This is shown in Figure 1-21.

The pressurizing (nitrogen) bottles are purchased from Air Reduction Co. The capacity of the bottles used at land sites is 224 cubic feet, at ship sites 112 cubic feet. Five to 10 pounds pressure is maintained in the heliax transmission lines.

Andrew Corp. bulletin 50922 gives installation, operation, and maintenance instructions for the patch panel.

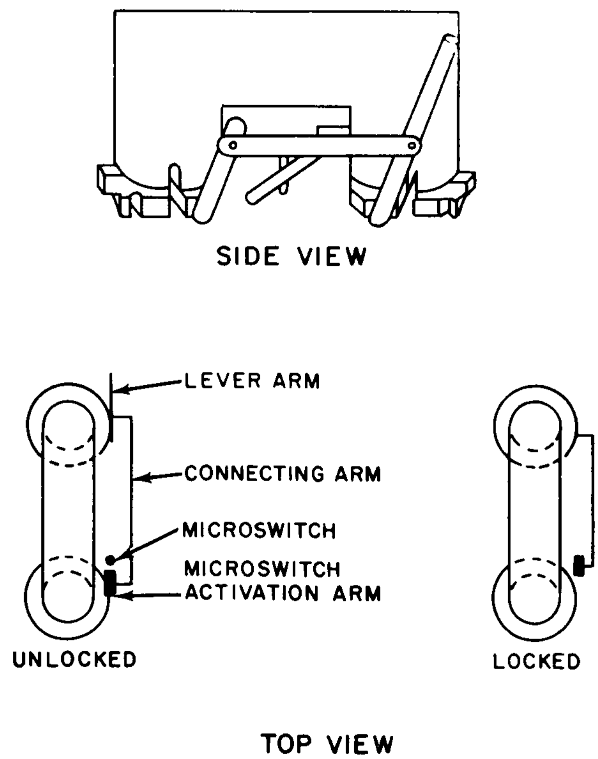


FIGURE 1-19. PATCH LINK

1.4.7 Dipole-Antenna Coupler DAC-8

Dipole antenna coupler DAC-8 is used with the shipboard horizontal-receiving antennas. It matches the antenna to the 50-ohm unbalanced RG-10A/U coaxial cable. The entire unit is contained within a sealed, fiberglass, reinforced, plastic case, and additional strength and weather resistance is provided by potting the transformer and connectors in a plastic compound. A built-in lightning arrester prevents the accumulation of static charges which otherwise might injure associated equipment. It has a frequency range of 2 to 30 mc. Over-all dimensions are 12-1/2 inches x 7-3/4 inches x 2-1/4 inches. This unit is shown in Figure 1-22.

1.4.8 Shipboard Filters, Receiving

To reduce interference between the transmitters and receivers aboard ship, filters are used on

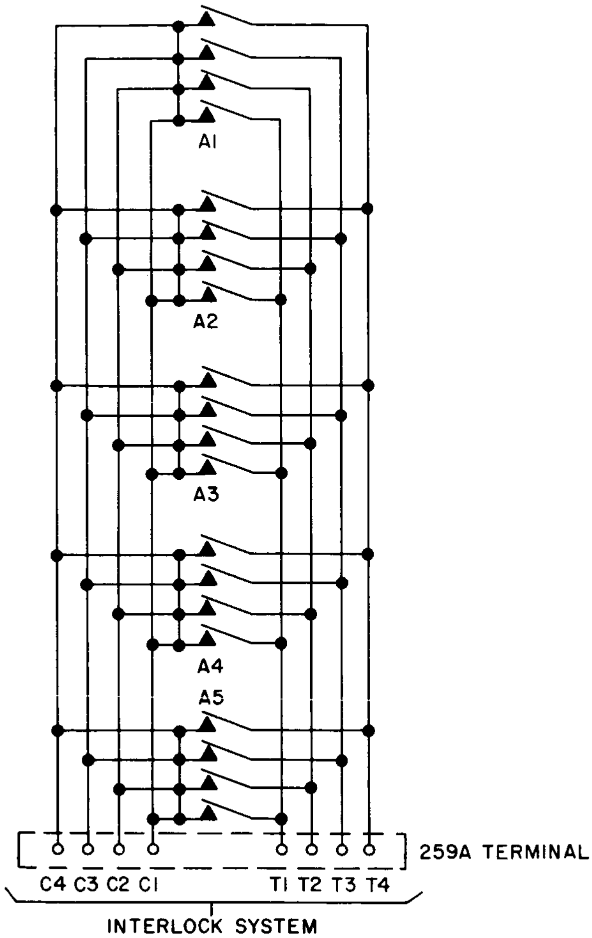


FIGURE 1-20. COAXIAL PATCH PANEL INTERLOCK CIRCUIT, KANO

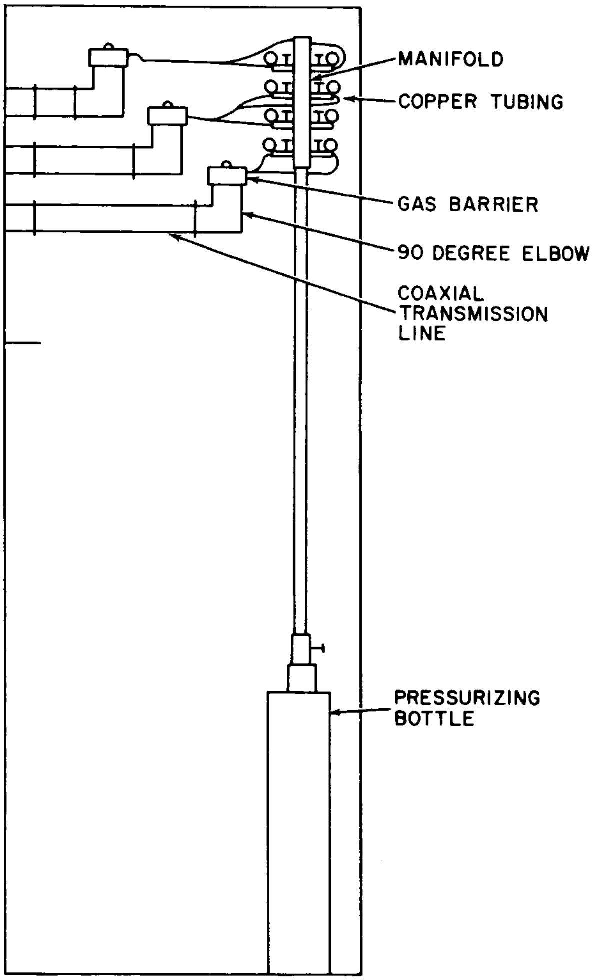


FIGURE 1-21. CABINET, INTERIOR VIEW

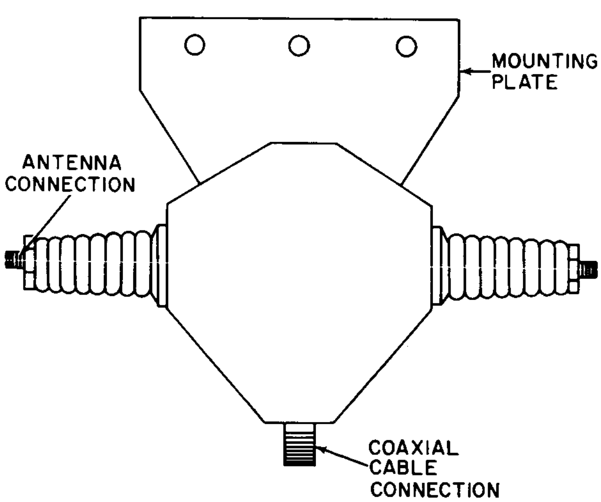


FIGURE 1-22. DIPOLE ANTENNA COUPLER, DAC-8

the hf transmitter and hf receivers. The receiver filters and the receiver-filter patch panel are shown in Figure 1-23. The filters are manufactured by Applied Research Inc., Port Washington, N. Y.

Drawing DP-11218 shows the receiver-filter patch panel cabinet which contains the filters, associated power supplies, antenna, and receiver coax-connectors so that any combination of antennas, filters, or receivers can be readily patched.

The receiver filter is type HFF-D-6/4. It consists of a sextuple-tuned filter followed by low-noise amplifiers followed by a quadruple-tuned filter. Each filter unit operates at a fixed frequency in the range of 6-24 mc.

The filters and amplifier combination are chosen to provide a minimum of 120 db or more of attenuation to transmitter frequencies located ±10 per cent from the operating frequency. The 3 db bandwidth maximum is ±1.5 per cent. This bandwidth is defined by the combination of

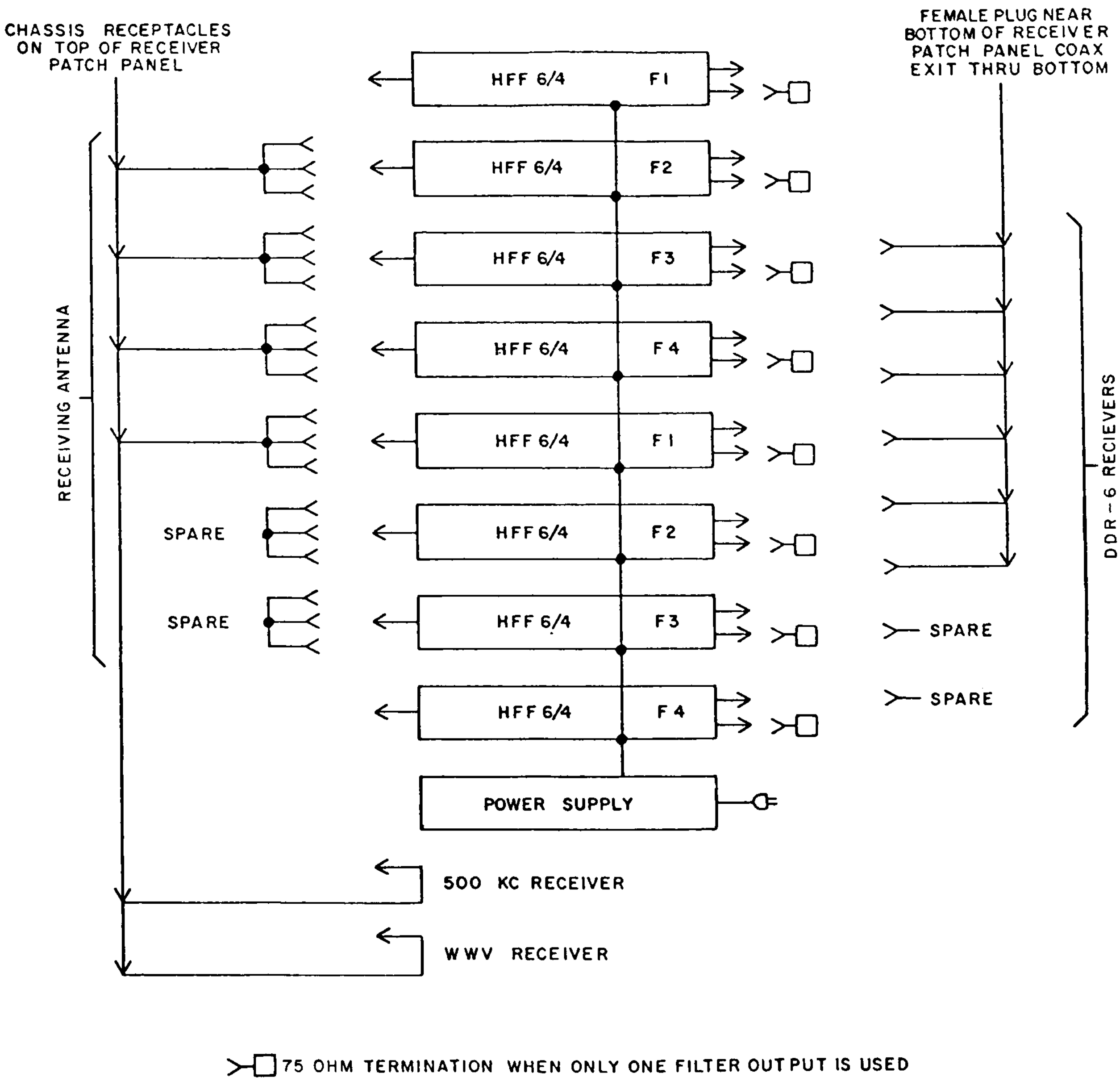


FIGURE 1-23. HF GROUND-TO-GROUND RECEIVER-FILTERS AND RECEIVER-FILTERS PATCH PANEL

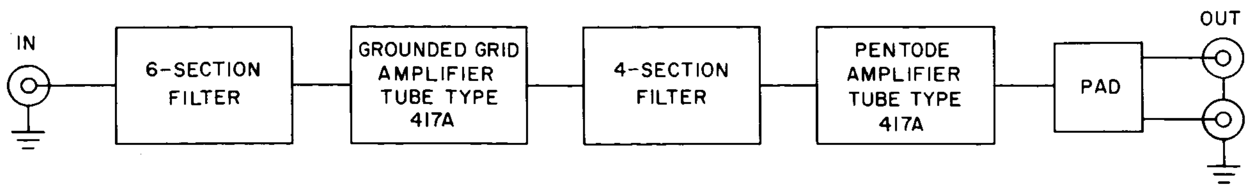


FIGURE 1-24. FILTER TYPE HFF-D-6/4, BLOCK DIAGRAM

the bandpass characteristics of the sextuple-tuned filter and the quadruple-tuned filter. The sextuple-tuned filters provide a minimum of 80 db rejection at ±10 per cent. The over-all noise figure for each channel is between 5 and 8 depending upon the frequency of operation. The contribution to the noise figure of the vacuum-tube amplifier is less than 3 db. The insertion loss of the sextuple-tuned filter varies between 2 to 5 db. The minimum power gain for the filter assembly is about 8 db.

One 50-ohm input connection is provided with a BNC-type connector. Two 75-ohm outputs terminate in TNC-type connectors. The unused output must be terminated with a 75-ohm termination when only one filter output is used, otherwise an improper impedance will result. To minimize the possibility of error between filters operating in one group of frequencies and filters operating in another group, the following mechanical characteristics are included:

a. Filters are clearly marked for frequency of operation.

b. All filters operating below 15 mc are painted gray.

All filters operating above 15 mc are painted black.

Figure 1-24 is a block diagram of the receive filter. The 6-section filter is shown in Figure 1-25. Figure 1-26 is a panel outline of the receive filter.

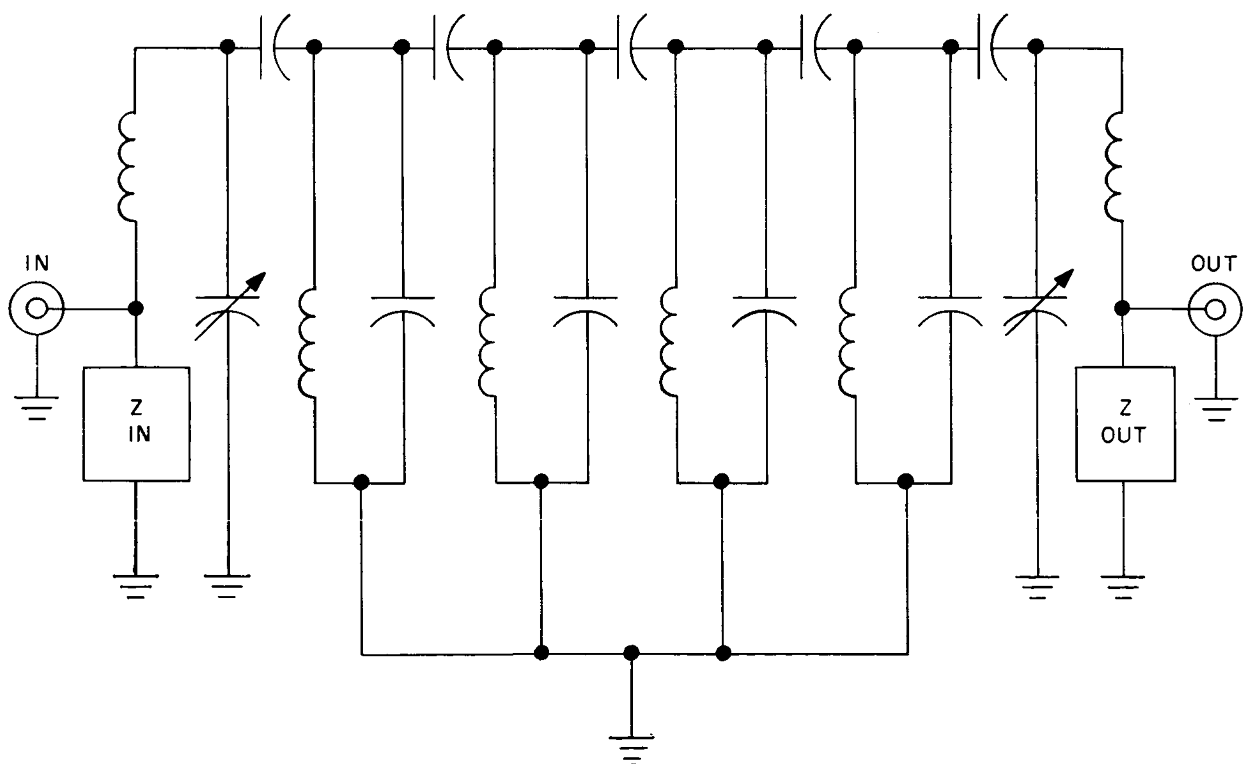


FIGURE 1-25. 6-SECTION FILTER, PART OF HFF-D-6/4

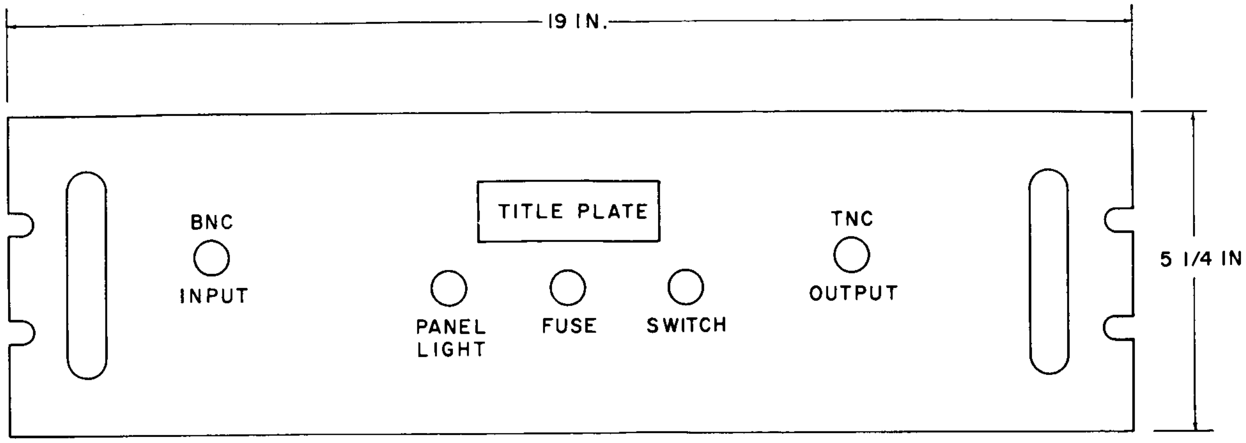


FIGURE 1-26. FILTER TYPE HFF-D-6/4, PANEL OUTLINE

By connecting two receivers to the two outputs of one filter, these two receivers can simultaneously receive RF signals anywhere within the ± 1.5 per cent acceptance band of the filter.

Detailed description, operation, and maintenance is given in ME-702, *HF Filters.*

1.4.9 Shipboard Filters, Transmitting

The hf transmitter filters consist of two paired filters, an exciter filter, type HFF-D-5, mounted inside the transmitter cabinet and an output filter, type HFF-3, mounted outside of the transmitter. The HFF-D-5 filter is connected between the output of the exciter and the input to the intermediate amplifier. The HFF-3 filter is connected to the PA output just ahead of the coax-patch panel. Figure 1-27 is a block diagram of the transmitter, filters, and coax patch panel. These filters are also shown in drawings T-6G03-172, T-6G07-172, and DP-11217. The filters are manufactured by Applied Research Inc.

The appropriate filters are connected to the transmitter depending on the operating frequency.

The HFF-3 PA filter is a triple-tuned filter for high-power rf operation. Each filter is fixed-tuned at a frequency in the range of 7 to 22 mc. These filters will handle a peak envelope power of 10 kw, with an insertion loss below 1 db. Blowers are included in the filter housing for cooling the filter. The input and output impedance are both 50 ohms, the connections are both 1-5/8 inch Heliax. The filter assembly is rf tight. A copper grounding bar is provided on the bottom of the filter assembly to permit adequate rf grounding of the filter. An interlock is provided to disable the transmitter upon removal of the filter. A panel light shows when the interlock is on. The HFF-3 filter provides for a minimum attenuation of 45 db at frequencies ± 10 per cent from f_0 and beyond within the range of 6 to 24 mc. At ± 1.5 per cent of the operating frequency, the maximum attenuation is 3 db.

Input loading and output loading adjustments on the HFF-3 filter should be used to minimize VSWR on the transmitter's station-guardian for each filter when used and when the antenna is changed.

Transmitter filter shorting unit HFF-DS permits transmitter operation without the output filter, type HFF-3. If the output filter develops trouble, or if it is necessary to operate on a frequency for which there is no filter, the shorting unit, HFF-DS, can be mounted in place of the HFF-3 PA filter.

CAUTION

The shorting unit, type HFF-DS, is always used on initial transmitter lineup, replacing it with the appropriate filter when the transmitter is trimmed to the antenna.

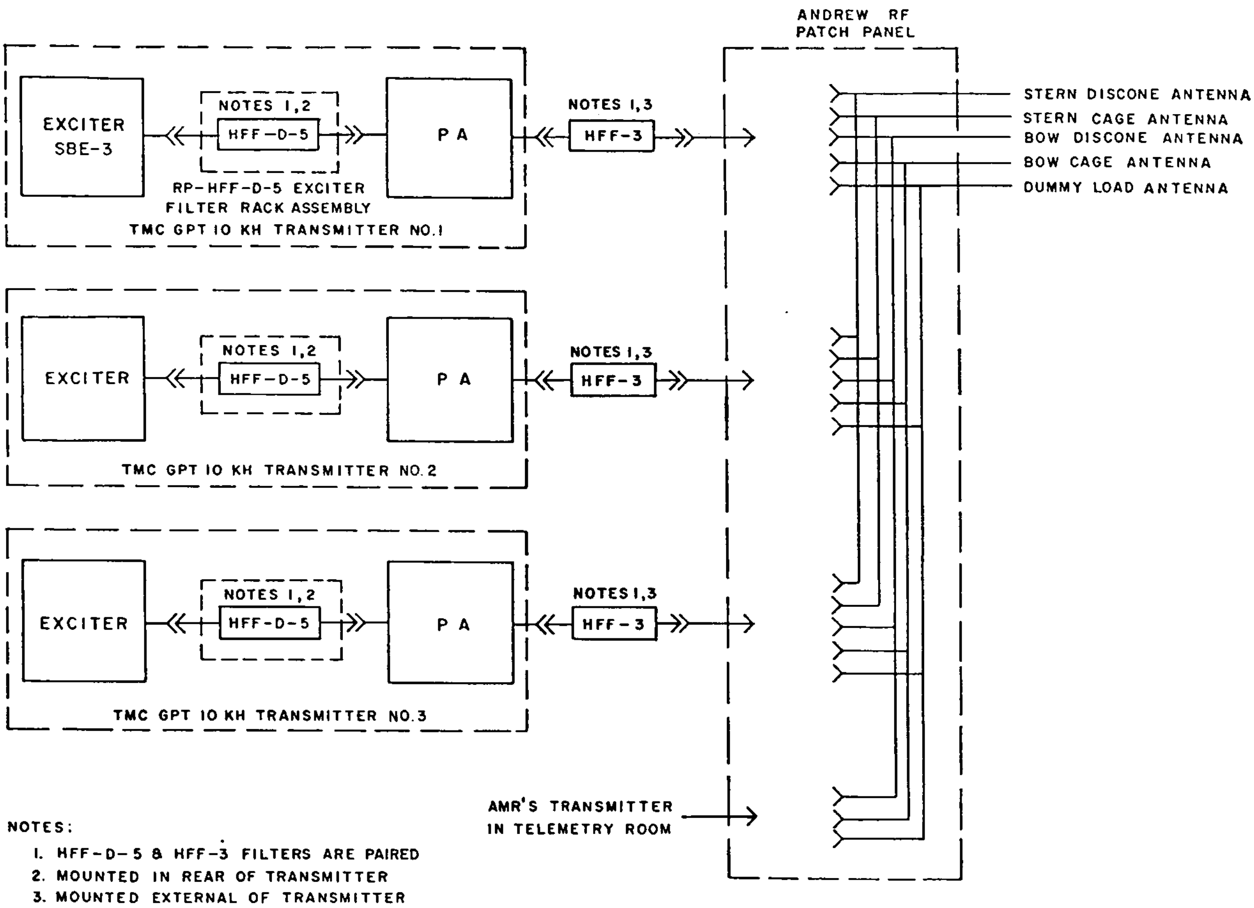


FIGURE 1-27. HF GROUND-TO-GROUND TRANSMITTER AND ASSOCIATED FILTER, BLOCK DIAGRAM

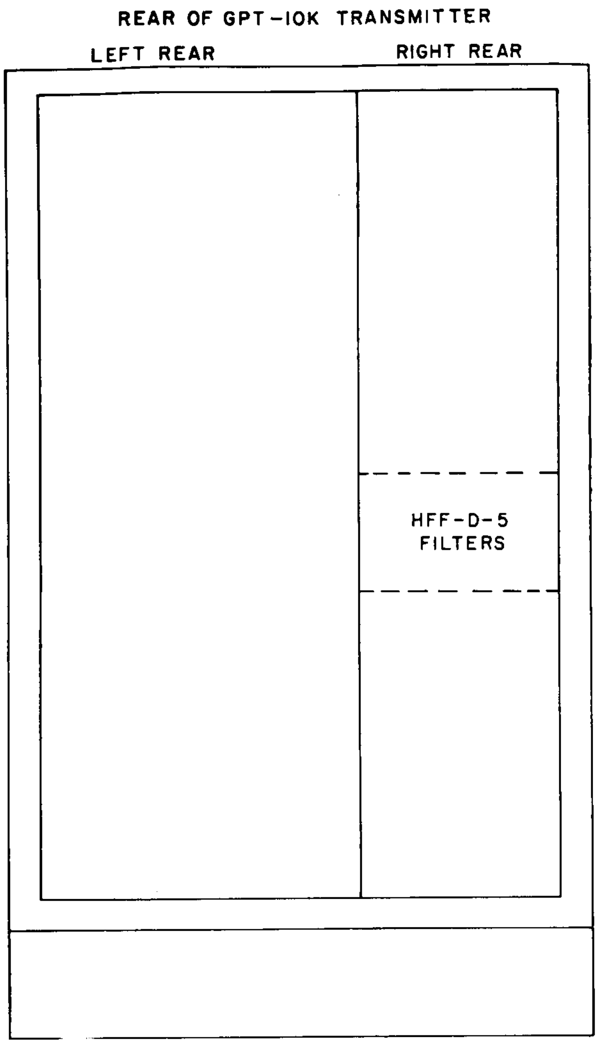
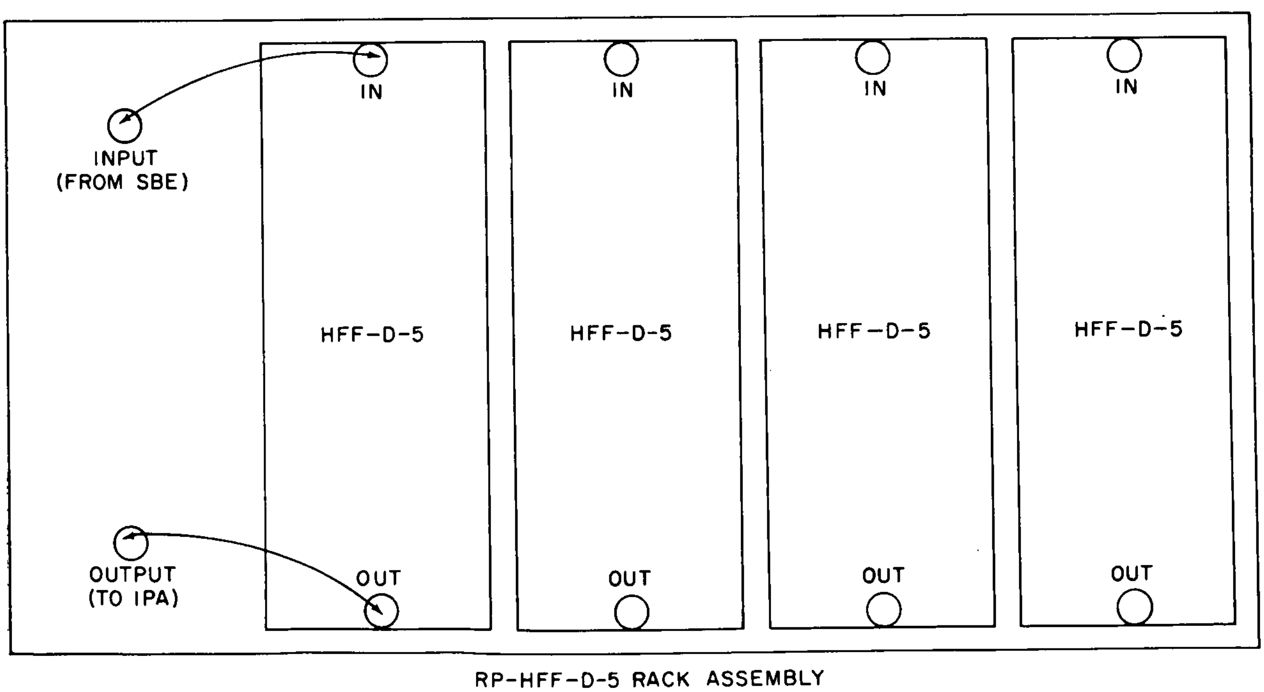


FIGURE 1-28. LOCATION OF FILTER, TYPE HFF-D-5

FIGURE 1-29. RP-HFF-D-5 RACK ASSEMBLY



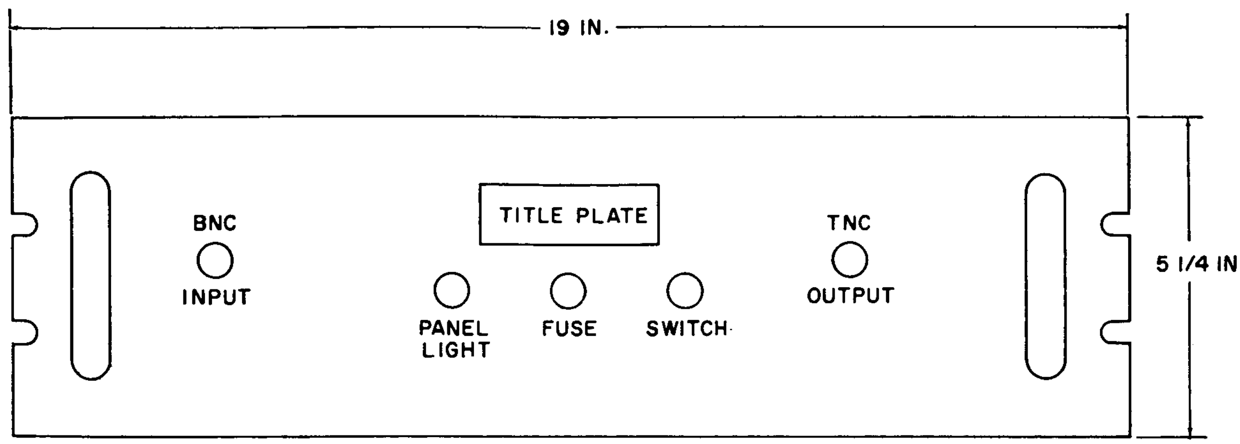


FIGURE 1-30. FILTER TYPE HFF-D-5, PANEL OUTLINE

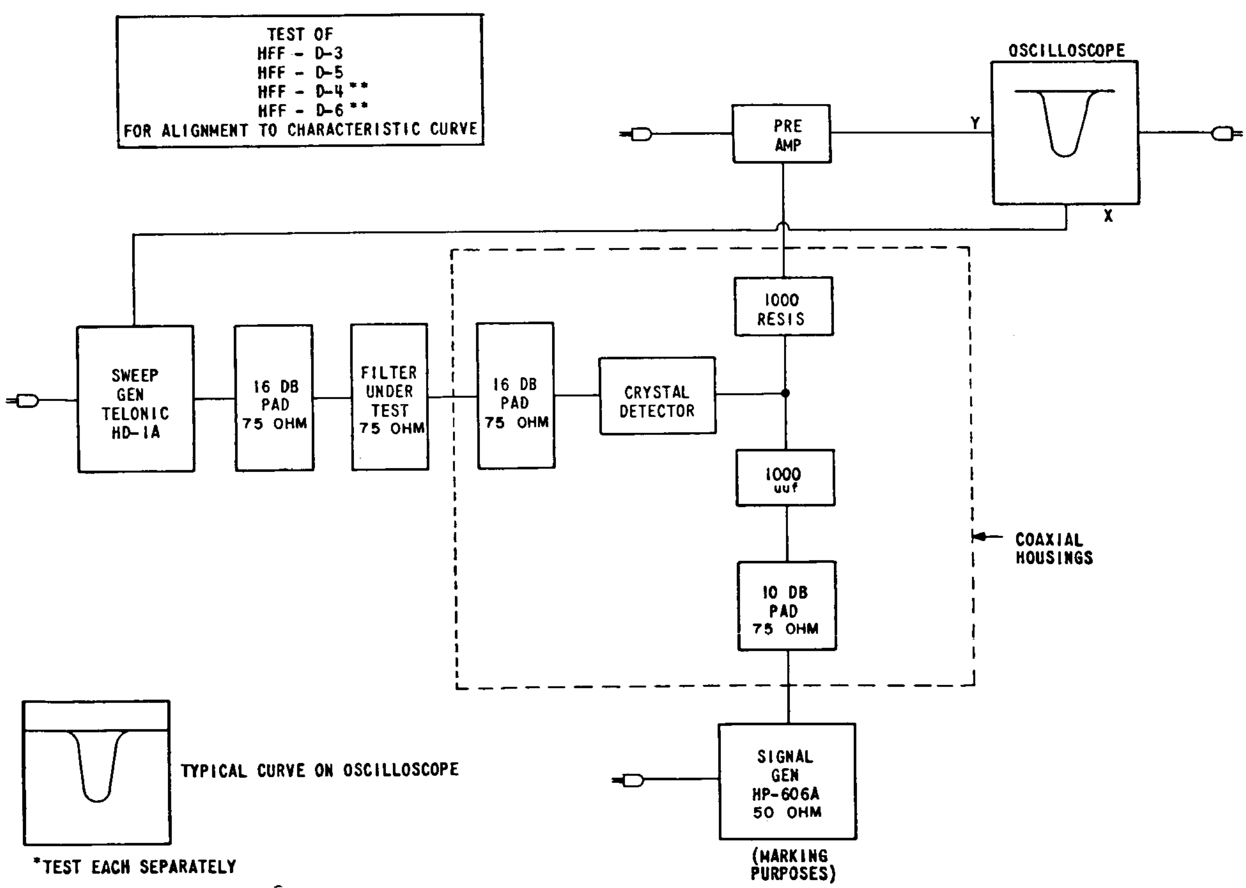


FIGURE 1-31. TEST OF FILTERS FOR ALIGNMENT CHARACTERISTIC CURVE

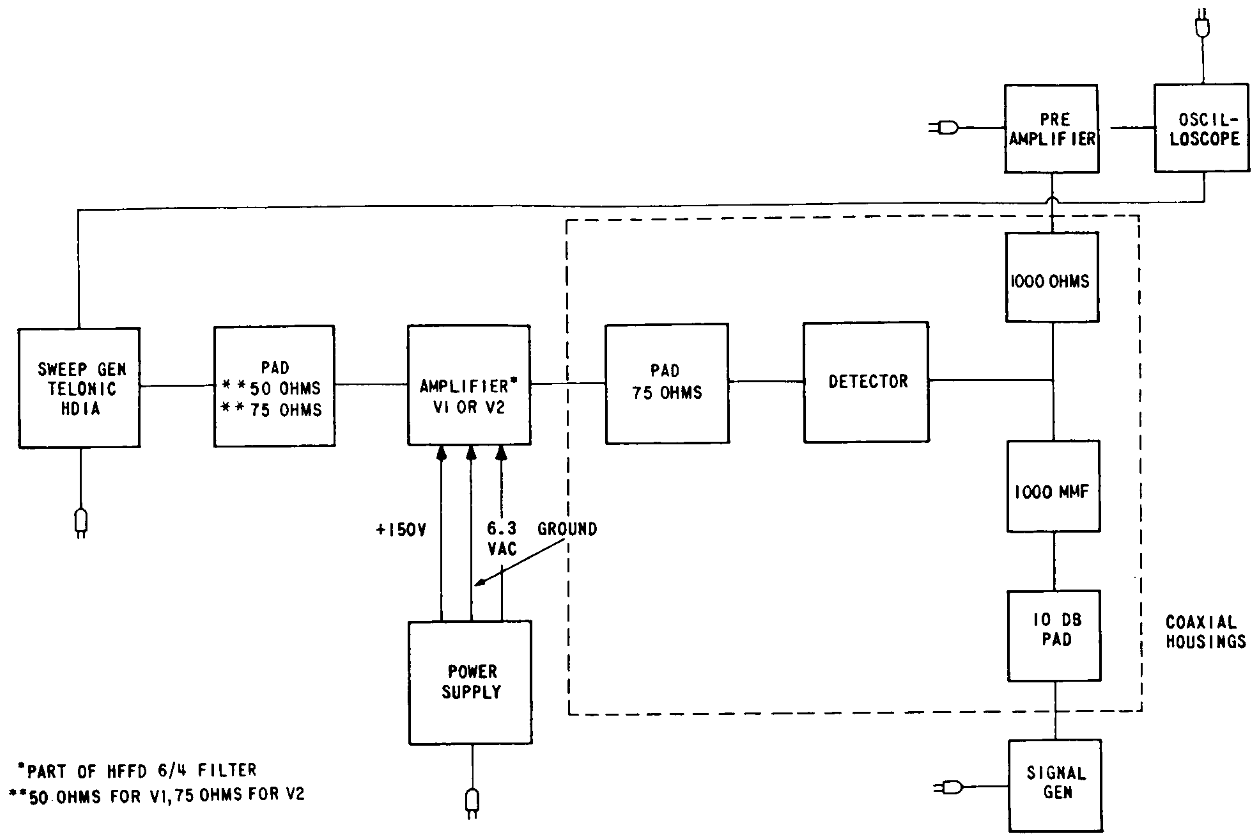


FIGURE 1-32. TEST OF UH-2 (C/D) AMPLIFIER FOR ALIGNMENT AND CHARACTERISTIC CURVE

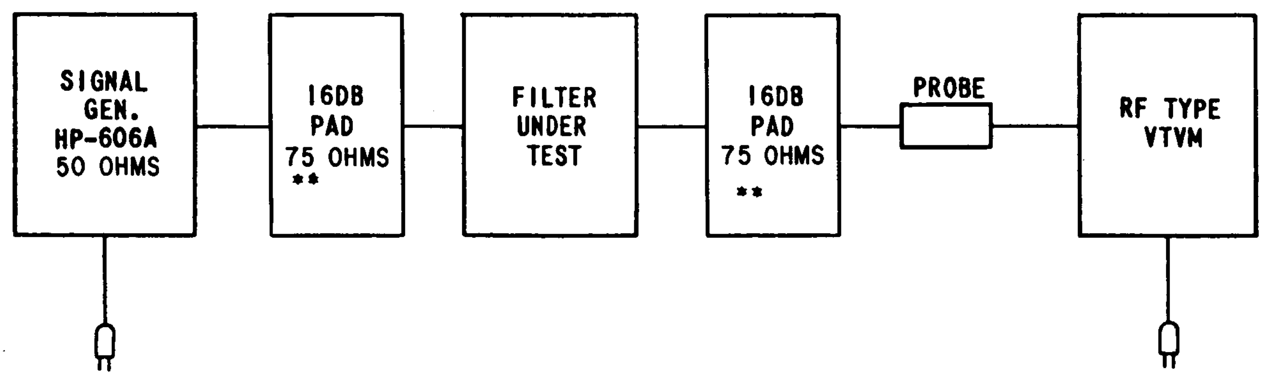
The HFF-D-5 exciter filter is mounted inside the transmitter cabinet; its location is shown in Figure 1-28. The exciter filter is a quintuple tuned (5 section), bandpass filter contained in a rack assembly, RP-HFF-D-5, which mounts inside the transmitter cabinet. One RP-HFF-D-5 assembly, is provided for each transmitter and holds four type HFF-D-5 filters. One BNC-type and one TNC-type female connectors are provided on the RP-HFF-D-5 assembly for proper connection of the assembly to the exciter and PA stages with which it will be used. Two cables are used to connect in the proper filter, depending on the operating frequency. Figure 1-29 shows the RP-HFF-D-5 rack assembly. At ±1.5 per cent of the center frequency of the exciter filter, the signals are attenuated 3 db, and at ±10 per cent of the center frequency, the unwanted signals are attenuated approximately 60 db. Both IN and OUT terminals are 75-ohm impedance. The exciter filter can handle 3 watts with maximum insertion loss of 6 db. Should a filter develop trouble or should it become necessary to operate on a frequency for which there is no filter, a special cable is provided which must be connected between the INPUT and OUTPUT jacks of the RP-HFF-D-5 assembly.

Figure 1-30 shows the panel outline of the HFF-D-5 filter.

Detailed description, operation, and maintenance of the transmitter filters can be found in ME-702, *HF Filters*.

Figures 1-31, 1-32, and 1-33 show the arrangement for checking the response of the filters. The items needed for these tests, except signal generators, vacuum-tube voltmeters, and oscilloscopes, are provided as a kit. The typical response curves are shown in Figures 1-34 and 1-35.

HFF-D-3
TEST OF HFF-D-5 FOR 3DB & 60DB POINTS
HFF-D-4*
HFF-D-6*



*TEST EACH SEPARATELY
**COAXIAL HOUSING

FIGURE 1-33. TEST OF FILTERS FOR 3DB AND 6DB POINTS

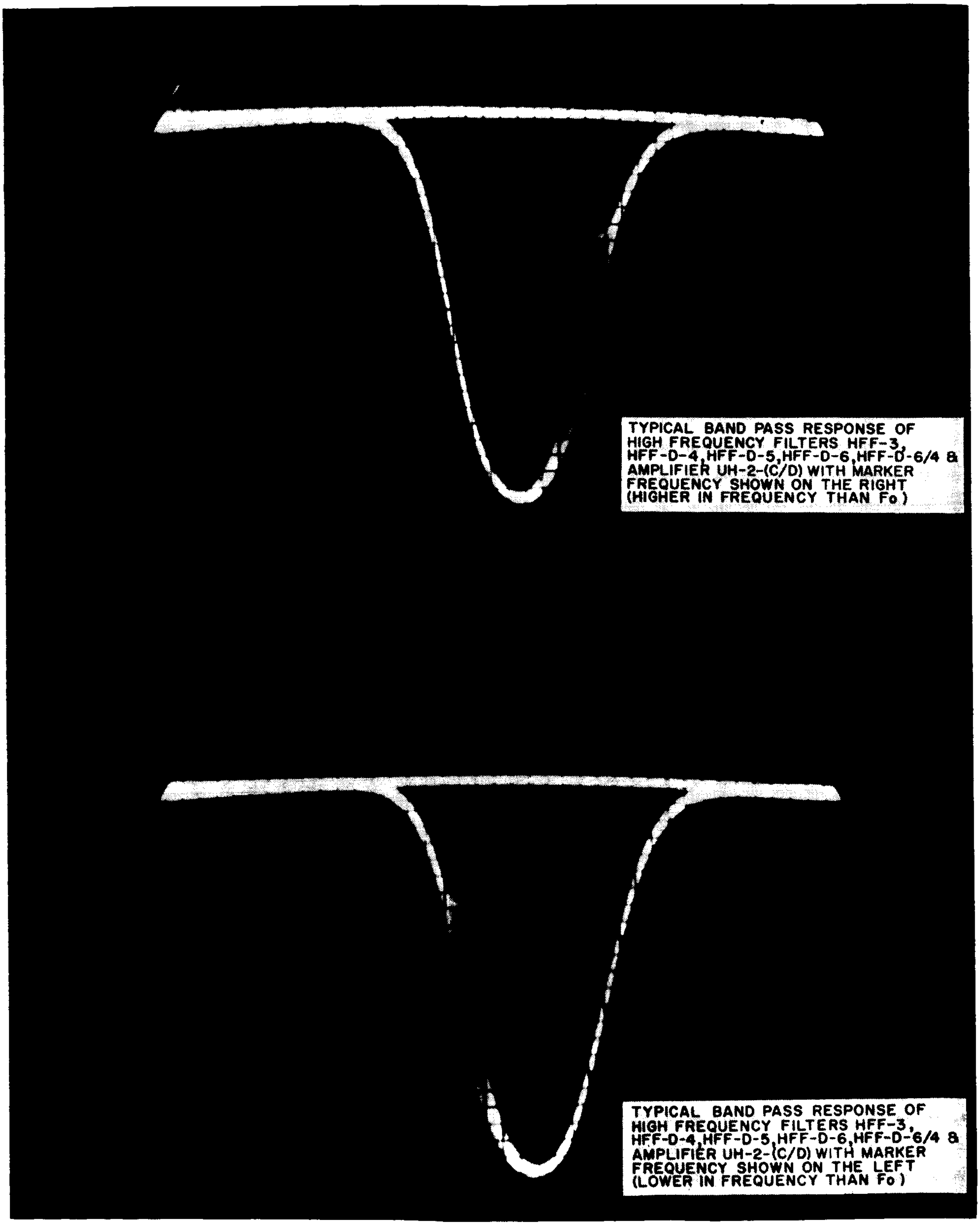


FIGURE 1-34. TYPICAL BANDPASS RESPONSE CURVES

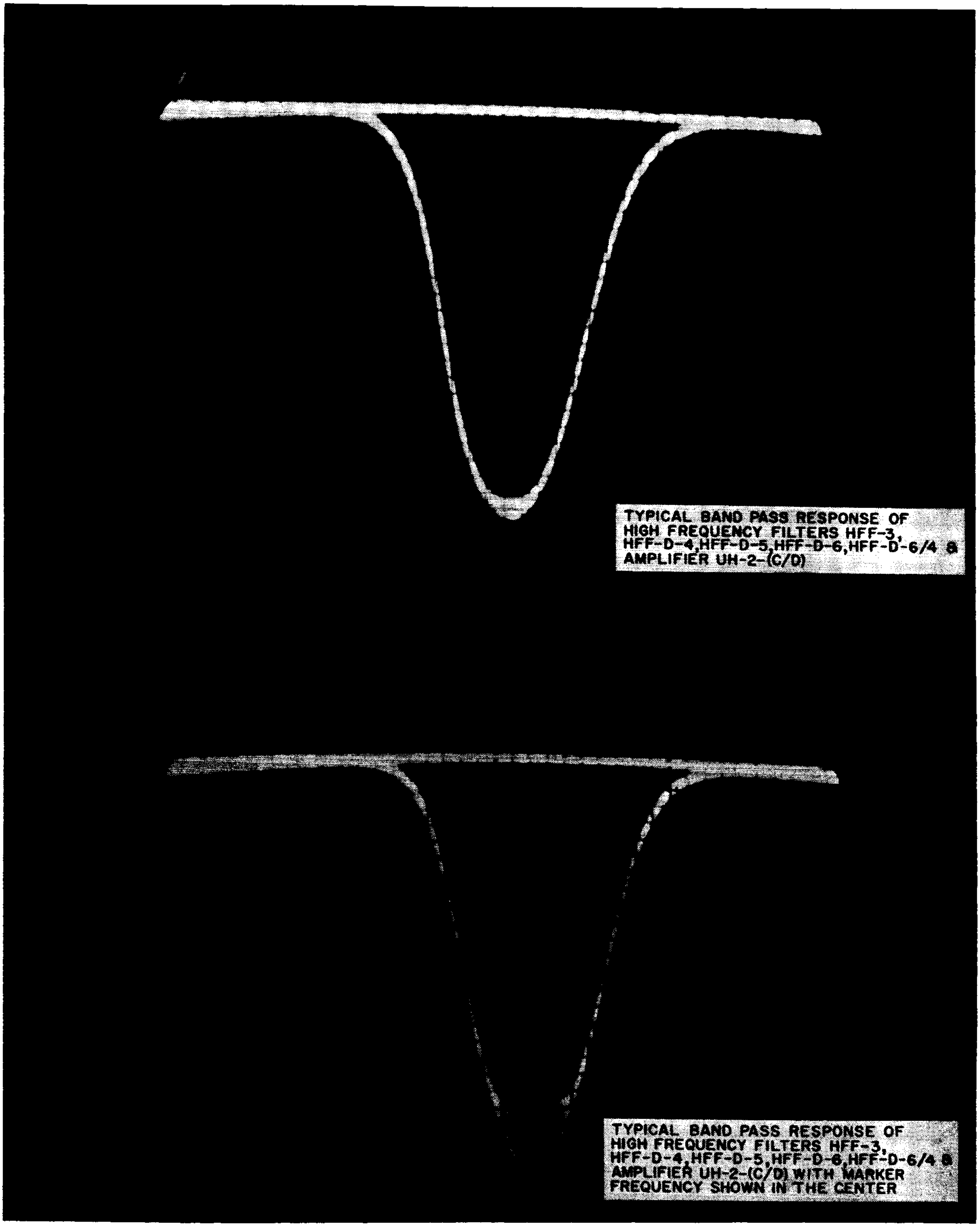


FIGURE 1-35. TYPICAL BANDPASS RESPONSE CURVES

SECTION 2. INSTALLATION

2.1 GENERAL INFORMATION

The installation of transmission lines includes the erection of open-wire transmission lines and exponential lines, placing of coaxial lines on poles and masts, placing of coaxitrans and baluns, and burying coaxial cable.

2.2 PLACEMENT

Detailed instructions for installing the transmission lines are covered in the −183 and −284 equipment specifications, together with manufacturers' instructions and Burns and Roe drawings. Paragraph 5.8 of this manual lists the drawings. Air-dielectric transmission lines are pressurized to 10 pounds per square inch.

2.3 SPLICING AND TERMINATING

Splicing and terminating the open wire and coaxial transmission lines is performed at installation in accordance with −183 and −284 equipment specifications, along with manufacturers' instructions and Burns and Roe drawings. The technician must refer to the above material for the maintenance of the transmission lines. The drawings are listed in paragraph 5.8 of this section.

SECTION 3. THEORY OF OPERATION

3.1 GENERAL INFORMATION

The transmission lines connect the antennas to the transmitters or receivers. Impedance-matching devices are used so that like impedances are connected together for a maximum transfer of energy.

3.2 BLOCK DIAGRAM

3.2.1 Atlantic Ship

The transmission lines are shown in Figure 3-1; dual-diversity (polar) reception from New York and the Canary Islands and transmission to New York and the Canary Islands is handled at this site.

3.2.2 Kano

Transmission and reception with London and Zanzibar constitutes the hf ground-to-ground communications at this site. Dual-diversity (space) reception is used. Figure 3-2 shows the transmission lines arrangements.

3.2.3 Zanzibar

Space-diversity reception from Kano and transmission to Kano is the communications provided at Zanzibar as the main radio path. Steerable log periodic antennas are used for emergency communications with the Indian Ocean Ship. Intrasite communication is provided by UHF

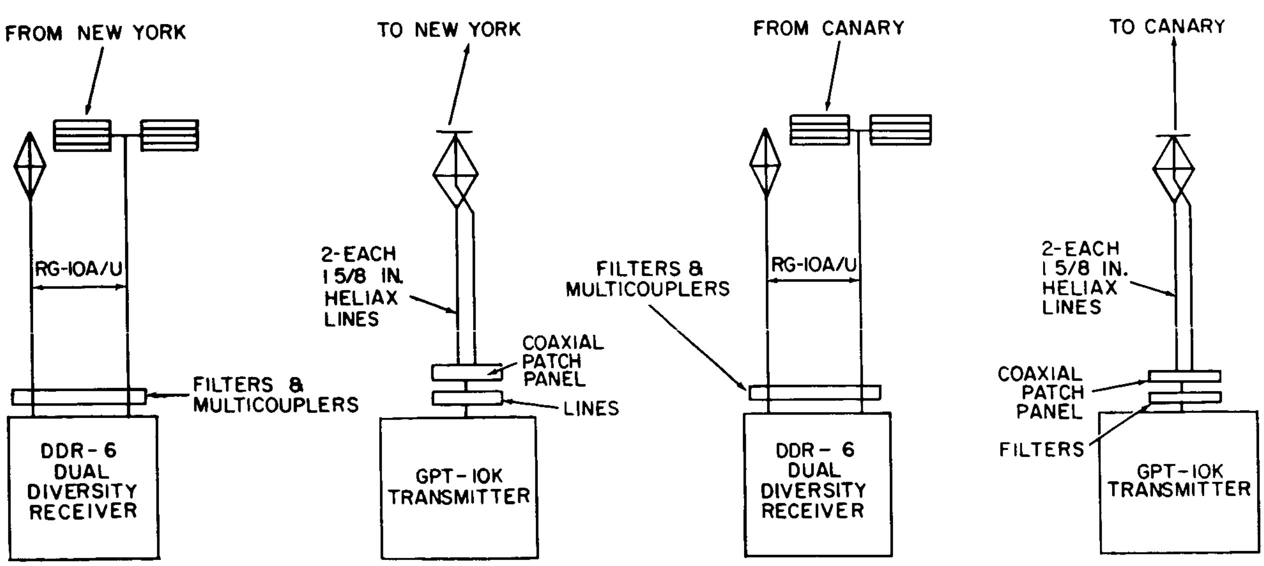


FIGURE 3-1. ANTENNA SYSTEM, ATLANTIC SHIP

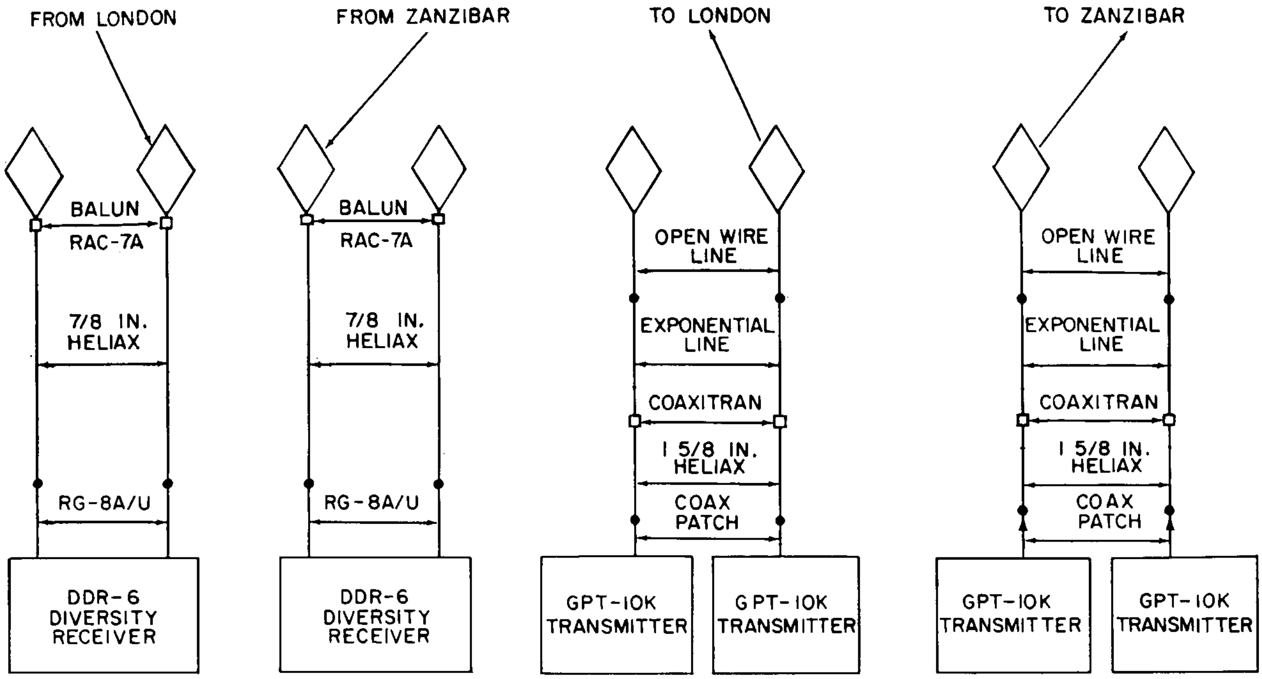


FIGURE 3-2. ANTENNA SYSTEM, KANO

using paraflector antennas connected to the transmitter and receiver with a 7/8-inch heliax cable. Figure 3-3 shows the transmission lines at Zanzibar.

3.2.4 Indian Ocean Ship

The transmission-line system on this ship is similar to that of the Atlantic Ship, providing radio service to Perth as the main radio path and to Zanzibar as the emergency path. Figure 3-4 shows the transmission lines.

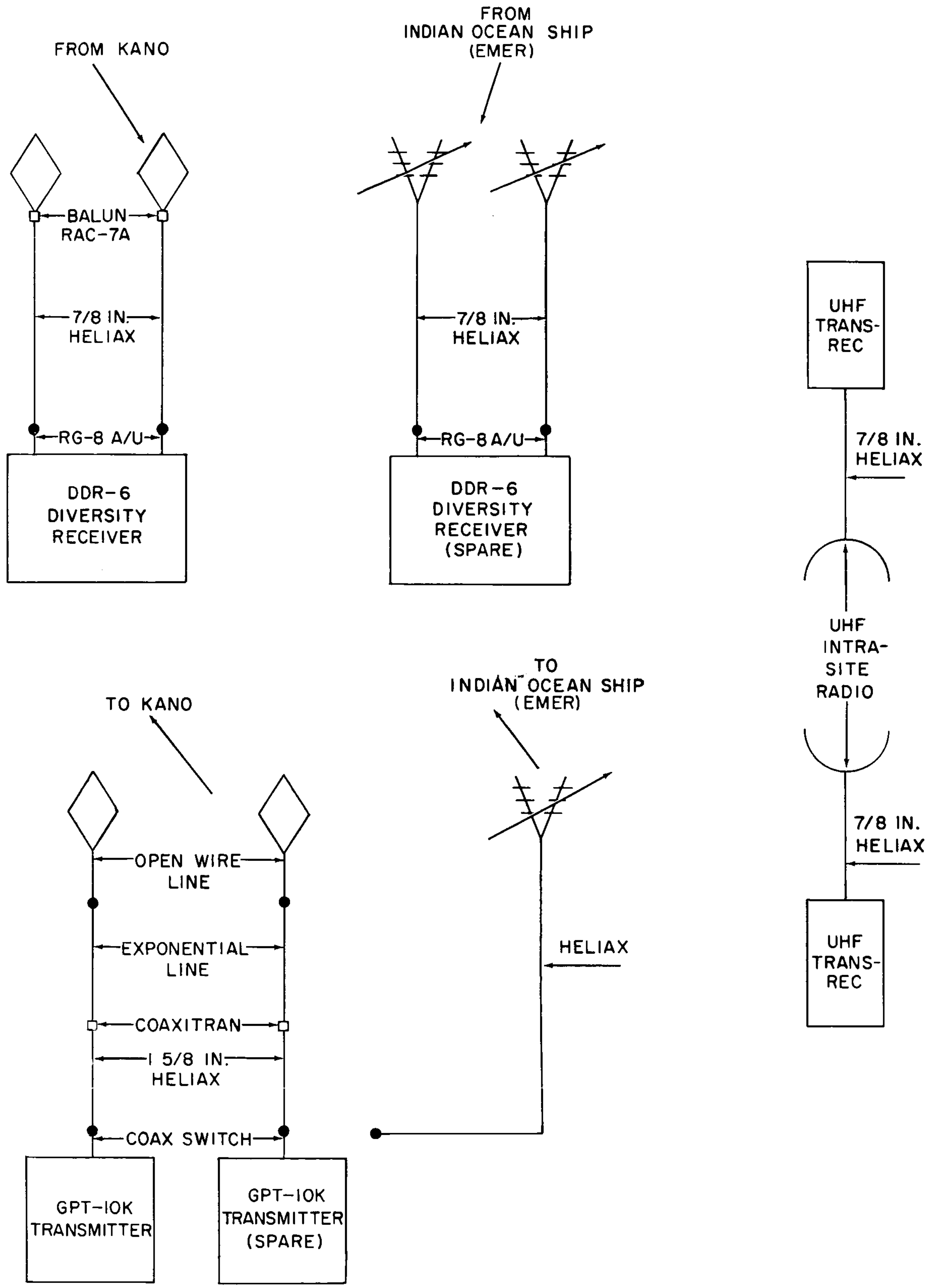


FIGURE 3-3. ANTENNA SYSTEM, ZANZIBAR

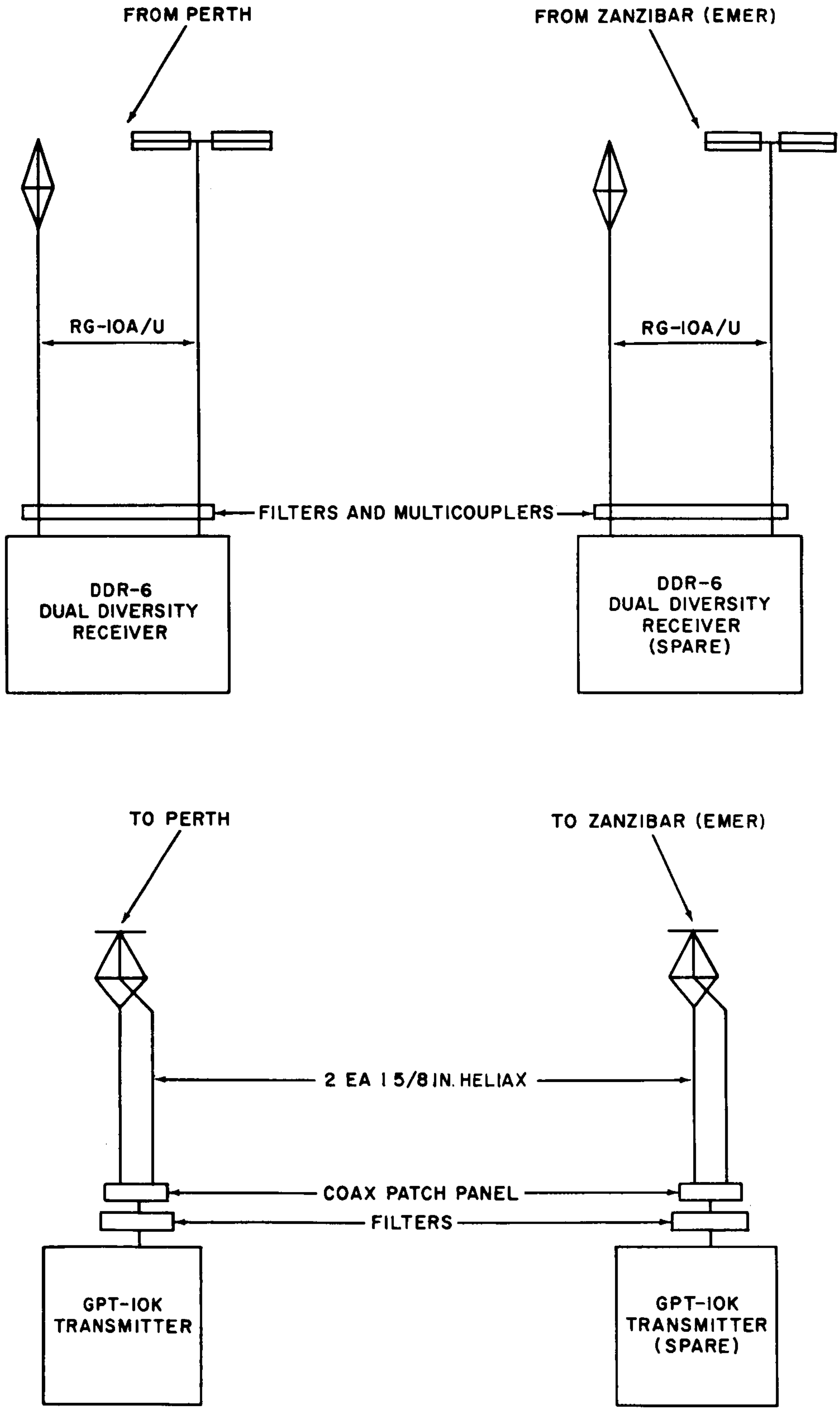


FIGURE 3-4. ANTENNA SYSTEM, INDIAN OCEAN SHIP

SECTION 4. SYSTEM OPERATION

4.1 HF RECEIVING SYSTEM

At a land site, the receiving rhombic antennas are connected to the hf dual-diversity receivers by coaxial cables. The impedance-matching device used between the antenna and the coaxial cable is the rhombic antenna coupler, Model RAC-7A, described in paragraph 1.4.5.

Figure 4-1 is a simplified diagram of the receiving antenna system at a land site. On board ships, RG-10A/U coaxial cable is used instead of the 7/8-inch heliax cable.

4.2 HF TRANSMITTING SYSTEM

Coaxitran 512F-1 and exponential line kit 512G-1:

The coaxitran and exponential line form a system for matching 50-ohm unbalanced impedances to 600-ohm balanced impedances in the 4- to 30-mc frequency range. In the Mercury application, these units match the 1-5/8-inch heliax-coaxial cable to the transmitting rhombic antenna.

Coaxitran 512F-1 is an impedance-changing transformer with an unbalanced input impedance of 50 ohms and a balanced output impedance of 200 ohms. The 50-ohm input is achieved by parallel connection of two sections of 100-ohm, rigid coaxial line. See Figure 1-8. One of these sections, L-2, is connected to cause a phase reversal between its ends by grounding the inner conductor at the 50-ohm input terminal and grounding the outer conductor at the 200-ohm output terminal. This section then serves as a 1:1 voltage ratio phase-reversing transformer. The phase inversion section, L-2, is wound into an inductance to minimize the shunting current across the 50-ohm terminal. This current corresponds to magnetizing current in transformer theory. In addition to the 180-degree phase shift due to the transformer action, there is additional phase shift due to finite velocity of the wave along L-2 considered as a transmission line. Compensation for this additional phase shift is achieved by feeding the inphase wave through coaxial-section L-1, electrically identical in length to L-2. The result is a balanced output with 180-degree phase difference between the voltage waves arriving at the output terminals of L-1 and L-2. Being connected in series, L-1 and L-2 present a balanced output impedance of 200 ohms.

The 200-ohm balanced output of the coaxitran is connected to the balanced input of the exponential line. The 600-ohm balanced output of the exponential line matches the 600-ohm open-wire transmission line feeding the transmitting-rhombic antenna.

Figure 4-2 is a simplified diagram of the transmitting-antenna system at a land site.

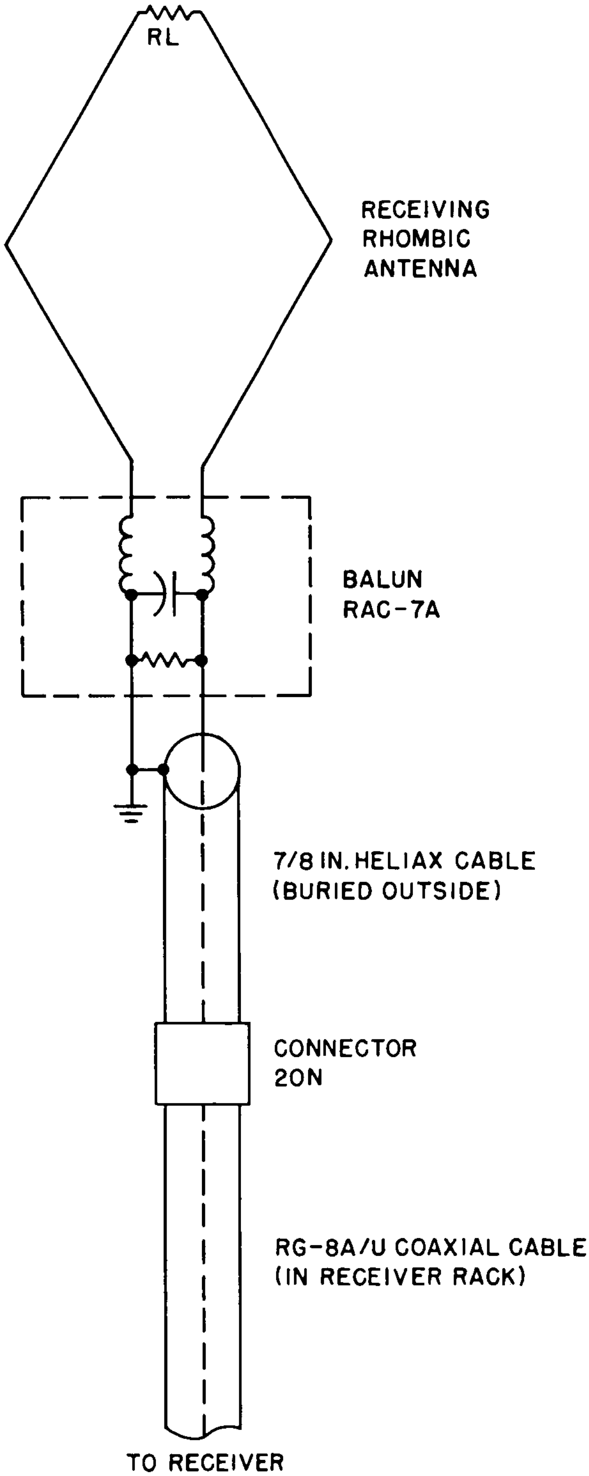


FIGURE 4-1. RECEIVING RHOMBIC ANTENNA SYSTEM (LAND SITES)

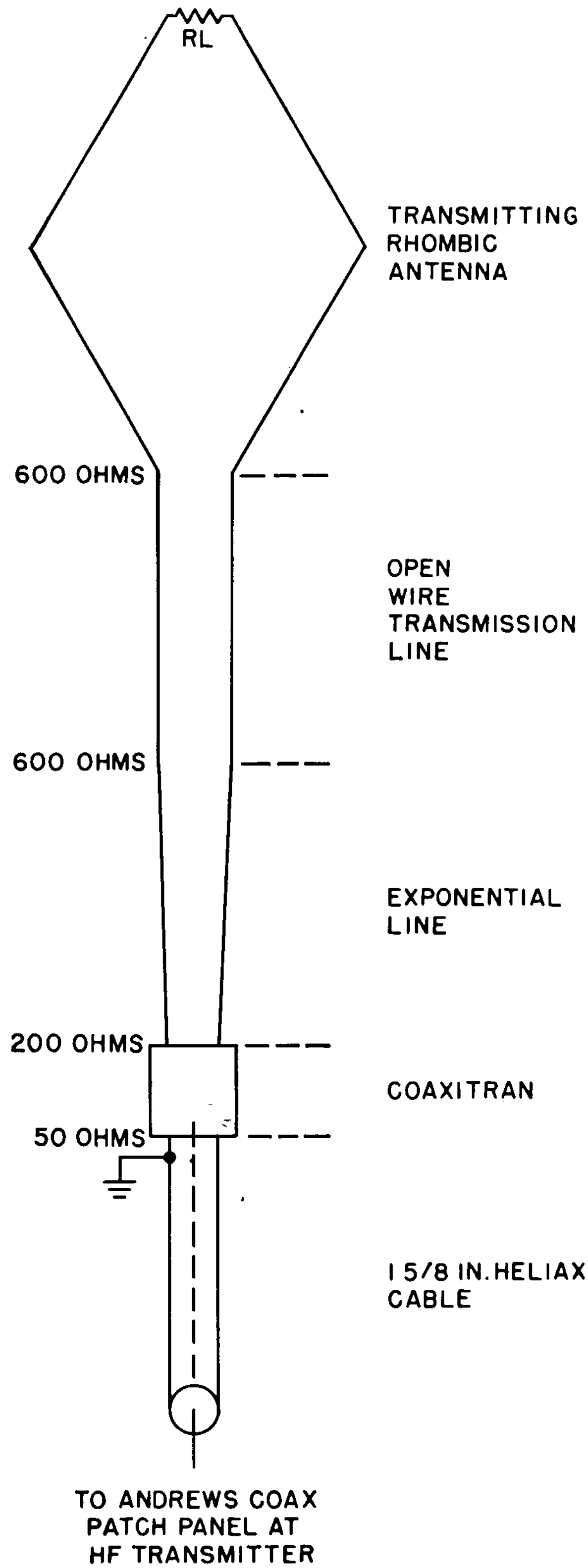


FIGURE 4-2. TRANSMITTING-RHOMBIC ANTENNA SYSTEM (LAND SITES)

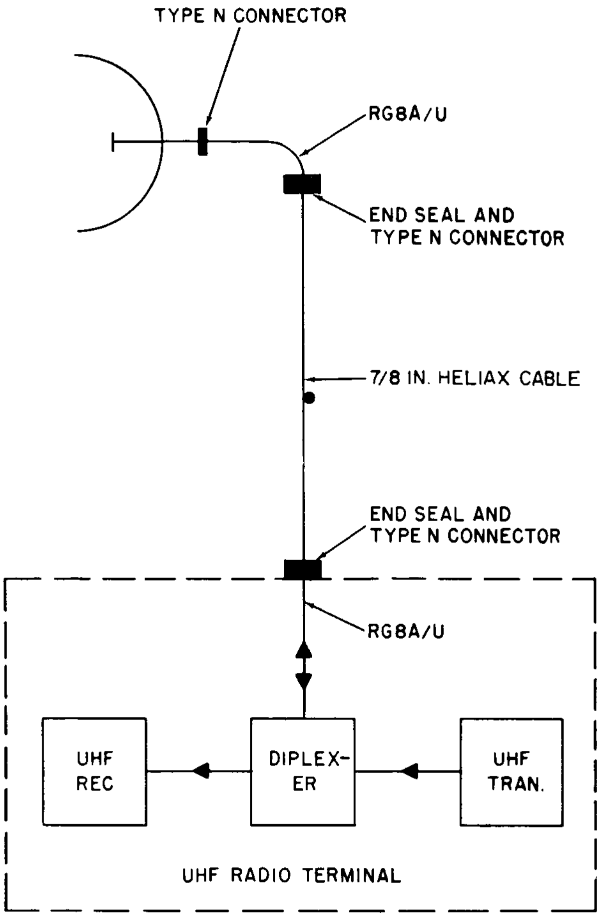


FIGURE 4-3. UHF TRANSMISSION SYSTEM

4.3 UHF TRANSMISSION SYSTEM

A 7/8-inch heliax-coaxial cable is used for the UHF transmission line as shown in Figure 4-3. A diplexer is coupled between the transmitter, receiver, and the antenna to permit both directions of transmission on a single antenna. The operation of the radio equipment is explained in Section VII of MS-109, *Intrasite PBX and Intercom.*

SECTION 5. MAINTENANCE

5.1 POLE CLIMBING AND SAFETY

5.1.1 General

The practices that promote safe work on poles are described in this instruction. Coverage includes safety precautions to be observed before attempting to climb poles, care and maintenance of pole-climbing equipment, safe pole-climbing procedure, and safety precautions for work aloft.

5.1.2 Preliminary Safety Measures

All personnel engaged in pole-climbing operations must know, understand, and observe the following preliminary safety measures and take precautions as required:

a. Be sure to be properly equipped for climbing and be sure that all equipment is in good working order. Check safety straps before each use.

b. Look for ground irregularities, large stones, or debris around the base of the pole. Clear away loose objects or debris and carefully note the position of any obstacles that cannot be removed.

c. Look for contact or insufficient separation between communication wires and power conductors or equipment on the pole or in adjacent spans.

d. If the work is to be performed on, or close to power conductors, contact the proper authority and arrange, if possible, to have the power turned off.

WARNING

A high rf voltage dangerous to life is present on the transmitting antenna and transmission line when the transmitter is in operation. Use caution when performing maintenance.

e. Perform maintenance work on the transmitting antenna only when the equipment is inoperative.

To render the equipment inoperative, follow the procedures listed below prior to performing maintenance on the antenna. Remove the primary power fuse from the fuse box. (Retain it until all work is completed.)

Place a DO NOT TOUCH, MAN WORKING sign on the transmitter. Discharge any capacitors that may be in the circuit by momentarily shorting the transmitter output to the transmitter cabinet or chassis ground with a grounding rod.

f. Wear insulated gloves or use a rod which is provided with an insulated grip to ground the transmitter output terminals. When working aloft, use body belt and safety strap. Check for the following conditions which may indicate that the pole is unsafe for climbing:

(1) Excessive rake or unexplained leaning of the pole.

(2) Evidence of lightning damage.

(3) Insufficient depth of pole setting.

g. Check for the following conditions which may demand extra care in climbing or in working aloft:

(1) Bent, loose, or missing pole steps.

(2) Presence of conduit or vertical runs on the pole which may interfere with climbing.

5.1.3 Apparatus and Tools

A body belt and safety strap are necessary to support worker's body on pole.

5.1.4 Selection and Care of Climbing Equipment

Selection and proper fit of clothing to be worn while climbing, and care of body belts and straps are described in the following paragraphs.

5.1.4.1 *Selection of Personal Clothing for Wear When Climbing*

a. *Shoes*—Shoes must protect the ankles as well as the feet. Soles must be reasonably heavy. Arch supports must also be included to protect the bones of the feet.

b. *Outer Clothing* — Clothing must be loose enough to permit free-body movement without binding. Loose ends of clothing are a hazard. Clothing must not be worn over the body belt.

c. *Safety Glasses*—Wear safety glasses or goggles.

5.1.5 Care of Body Belts and Safety Strap

5.1.5.1 *Inspection Routine*

Safety requirements demand regular inspection of body belts and straps, and strict attention to proper cleaning and storage methods.

Each employee, when receiving a body belt and safety strap, must inspect them in accordance with paragraph 5.1.5.2 at least once a week thereafter, so that he may detect any fault which may have developed.

Each employee must at all times assume the responsibility for determining that his body belt and safety strap are in good condition and that its appearance indicates neither deterioration nor injury sufficient to affect its strength.

5.1.5.2 *Inspection of Body Belt and Safety Strap*

The belt and safety strap must be examined to determine the condition of all parts as suggested below. If any of the following conditions are found to exist or if the condition of the belt or holster is such that there is any doubt as to its safety, it must be exchanged at once for one in good condition.

a. *Visual Inspection*—The important conditions to look for are:

(1) Broken steel reinforcement plates holding dee rings.

(2) Leather of loop over reinforcing plates worn or crushed by the dee ring at the edges sufficiently to affect its strength or to cause the leather to tear.

(3) Loose or broken rivets (particularly those in the loops holding the dee rings).

(4) Broken or rotted threads in the stitching of the loops holding the dee rings.

(5) Cracks, cuts, etc, that would tend to cause the leather to tear or would be likely to affect the strength of the belt.

(6) Leather hard and dry. (If the leather requires only oil, it should be treated as outlined in paragraph 5.1.5.3.)

(7) Broken wrench keeper.

(8) Broken or defective buckle.

(9) Burnt leather.

Leather with hard spots, a curved set or indistinct portion of the ironed crease along the edge, as well as leather having a burnt streak across the face may have become burned by being subjected to excessive heat. This may have happened to a belt in any of the following ways:

(1) Placing the belt against or near hot steam pipes, radiators, or heaters.

(2) Placing belt near a pot of hot solder, hot soldering copper, or a splicer's furnace.

Leather which has been heated excessively becomes hard and brittle when it dries. If partially burned, a crystalline substance forms in the inside of the leather. These spots have sometimes been mistaken for defects in the leather such as blood clots, chemicals deposited in the hide while being tanned, or glue used in connection with piecing out leather.

b. *Visual Inspection of Leather Tool Holster:* The important conditions to look for are:

(1) Loose or broken rivets.

(2) Broken or rotted threads in stitching.

c. *Bending Test for Leather*—This test must be made on body belts only when the leather is clean and well oiled. The leather must show no cracks other than slight surface cracks when the test is applied. If well defined cracks appear, the belt must not be used, but must be taken out of service. The test must not be made if the temperature of the leather is below 32° F, since at low temperatures the leather may be damaged by bending it around the test mandrel.

(1) Leather must be bent with the grain (smooth) side out, over a mandrel that is not less than 3/4-inch in diameter (a 3/4-inch guy rod may be used). In making this test, pull the leather taut, and wrap it half way around the mandrel, keeping the leather under tension while the bend is being made. This procedure brings the leather into firm contact with the mandrel while the bend is being made, and thus avoids bending the leather too sharply. Do not loop the leather first and then pull it over the mandrel. Do not make the bend test at a buckle hole.

(2) Body belts must be subjected to the bend test at points where it is possible to bend them, such as under the leather tool loops and at the tongue strap.

If the leather is subjected to an excessively severe test, such as bending it too sharply (without a mandrel or over too small a mandrel) with the grain side out, good leather may crack because of the excessive strain placed on the grain layer.

5.1.5.3 *Care and Maintenance*

a. *Cleaning and Dressing*

Body belts and straps must be cleaned and dressed at intervals of not more than three months. These intervals must be shortened if the body belt has been frequently wet from rain or perspiration or in cases where the belt is subjected to contact with wet paint. When the body belt is used in connection with the painting of poles, carefully remove any wet paint from the belt with a dry cloth, as the ingredients in the paint, if allowed to dry on the leather, may have an injurious effect on it.

Tests indicate that creosote is not injurious to leather. However, because the creosote may stain the workman's clothing, it must be removed from the body belt as soon as practicable.

The following method has been found satisfactory for cleaning and dressing the leather:

(1) Wipe off all surface dirt with a sponge dampened (not wet) with water. (Never use gasoline because it tends to cause a dry condition of the leather.)

(2) Rinse the sponge in clear water and squeeze partly dry, then work up a thick lather using a neutral soap, such as castile or white toilet soap (free from alkali).

(3) Thoroughly wash the entire length of the leather with the lathered sponge to remove embedded dirt and perspiration and wipe with a cloth to remove excessive moisture.

(4) Proceed as in (2) using a good grade of saddle soap.

(5) Work the saddle soap lather well into all parts of the leather and place the article in the shade to dry.

(6) When the leather has practically dried, rub vigorously with a soft cloth.

b. *Oiling*

Body belts and straps ordinarily require oiling about every 6 months.

The following method has been found satisfactory for oiling the leather so as to restore it to a pliable condition:

(1) Clean the leather with a neutral soap as described in paragraphs above. (Oil applied to dry or dirty leather has a harmful effect on the leather.)

(2) While the leather is still damp, use about 1/4-ounce (two teaspoonfuls) of neatsfoot oil on each belt and apply the oil gradually with the hands using long light strokes to work it into the leather. A light even distribution of the oil is desired.

NOTE

Do not use mineral oils or greases such as machine oil or vaseline. Leather must never look or feel greasy, because this is an indication that too much oil is being used. Leather with too much oil stretches and is likely to pick up sand or grit which may injure the leather.

(3) After oiling, set aside in a dry shady place for about 24 hours in order to permit the leather to dry slowly; then rub vigorously with a soft cloth to remove excess oil.

c. *General Precautions*

The following precautions must be observed when body belts are not in use:

(1) In the event that a body belt is received with insufficient oil, it must be oiled in accordance with subparagraph b. above.

(2) When not in use, body belts must be oiled at least once every 6 months. The belt must be oiled 3 months after it has been received for stock and at intervals not longer than 6 months thereafter, as long as it remains in stock.

(3) Body belts must never be stored with edged tools. When body belts, safety straps, and climbers are kept in the same container, the climbers must be fitted with gaff guards to prevent damage to the leather by the climber gaffs.

(4) Never store or place body belts near radiators, stoves, steam pipes, or in places where the leather would be subjected to excessive heat or dampness. Either of these conditions is likely to impair the strength of the leather. Belts that have become wet must be treated as described above and then set aside in a dry, shady place and allowed to dry slowly.

d. *Disposition of Body Belts Requiring Repairs*

Body belts and straps which have developed major defects must be withdrawn from service for repairing or junking. Employees in the field must see that such belts in their possession are tagged or marked, DANGEROUS, DO NOT USE and if practicable, the belt must be marked to show the location of the defect.

5.1.5.4 *Safety Precautions*

The following precautions should be observed when using body belts and safety straps.

a. Wear body belts and safety straps at all times when working aloft on poles (including stepped poles), cable cars, splicers' and other aerial platforms, and ladders lashed to strand or otherwise secured.

b. Do not fasten an uncoiled hand line directly to a belt or to tools hanging on a belt when climbing or working on a pole. Either of the following two methods provide a safe means of carrying or supporting an uncoiled hand line aloft.

(1) Form the end of the hand line into a loop and place the loop in the hand line carrier.

(2) Form the end of the hand line into a bight and tuck the bight up under the body belt. If the hand line should get caught on either an obstruction or a passing vehicle, and the hand line is attached by either of the above methods, the hand line will be pulled free and the workman will not be pulled off the pole.

c. Never punch extra holes in a body belt.

d. Do not use the body belt to assist in piking holes. In the event that the workman slips or stumbles, the pike pole may slide down between the belt and the body and cause serious injury.

5.1.6 Safe Pole Climbing Techniques

The safety procedures to be followed before climbing, while climbing and descending, and while working aloft are detailed in the following paragraphs.

5.1.6.1 *Procedure to be Followed Before Climbing the Pole*

Safe pole climbing begins on the ground. Comply with the following:

Be sure all preliminary-safety measures (paragraph 5.1.2) have been carried out.

Check clothing and climbing equipment for good condition, proper fit, and absence of any loose ends of clothing. Adjust the safety strap as shown in Figure 5-1. Stand with feet against the pole, grasp the pole at shoulder height, and lean straight back. Adjust the strap so that it is just barely taut. A strap that is too short limits freedom of movement and hampers control of body balance by bringing the knees too

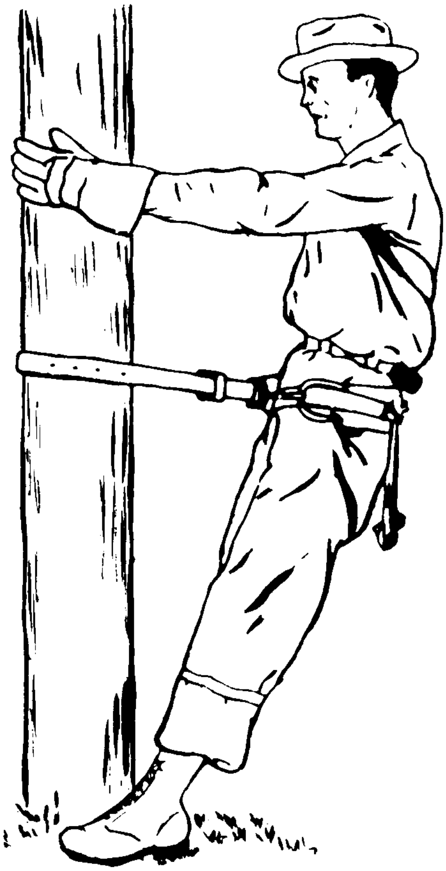


FIGURE 5-1. PROPER LENGTH OF SAFETY STRAP

close to the pole. A strap that is too long causes strain on the leg and back muscles.

Plan to mount the pole from the leeward side whenever possible or on the high side of a pole that is leaning.

5.1.6.2 *Precautions for Climbing a Stepped Pole*

Never trust a step to support body weight without testing it.

Carefully ease the weight onto each step, maintaining a firm grip with both hands on the steps above, so as to support the body if a step should fail.

Clean accumulated ice, snow, or mud from pole steps as the pole is ascended.

5.1.6.3 *Procedure for Placing the Safety Strap*

Maintain body balance with one arm. Carefully ease one arm off the pole and disengage one of the safety-strap snaps from the dee ring.

Bring the hand up to the pole, holding the dee ring as shown in Figure 5-2, and carefully transfer support of the body to this hand.

With the free hand, take hold of the strap (Figure 5-3) and engage the strap in the dee ring. Look, see, and know that the strap is properly engaged. Never rely on sound alone.

Carefully lean back until the body weight is transferred to the safety strap. Then, and only then remove the hands from the pole.

5.1.6.4 *Safe Procedure for Work Aloft*

Safe procedures for work aloft are given in the following paragraphs.

a. *Safe Procedures for Raising Tools and Equipment*

Never carry tools or equipment in the pockets, or throw them from hand to hand. Use the hand line.

Carry the hand line carefully coiled and attached to the body belt.

If one end of the hand line must be secured to something on the ground and the other end

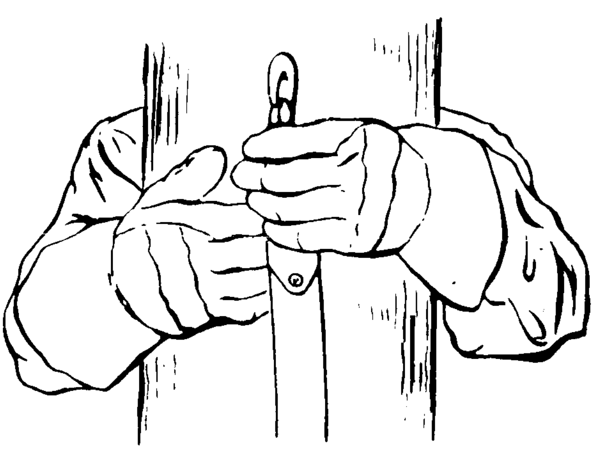


FIGURE 5-2. PLACING SAFETY STRAP, STRAP IN POSITION FOR TRANSFER

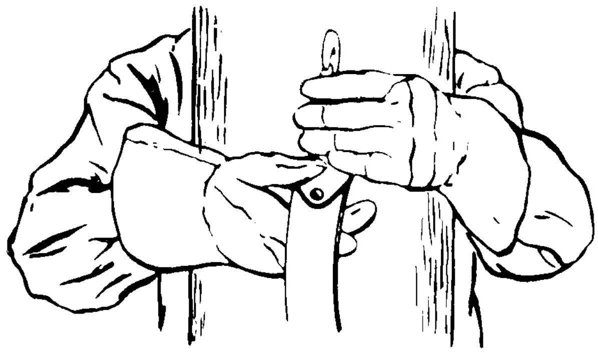


FIGURE 5-3. PLACING SAFETY STRAP, TRANSFERRING STRAP FROM HAND-TO-HAND

carried up the pole, loop the free end of the hand line beneath the body belt at the back, so that it will easily pull free if any obstruction is encountered. There is danger of being pulled from the pole if the hand line is tied to any part of the body.

b. *Safe and Efficient Work Positions*

Keep the body positioned high enough, so that work can be performed near elbow level.

Keep the safety strap tight. Shift the hips as body position is changed, so as to keep about equal safety strap lengths on each side of the pole.

Try to plan the work so that the force of any operation such as lifting, pulling, and tightening is directed away from the head.

When lifting, keep a secure footing, back straight, head up, and lift with the legs rather than the arms. Keep the center of gravity of the load close to the body. Use two men, or a hand-line and snatch block, if there is any doubt as to whether the load can be handled by one man. When ascending or descending a short distance, keep the safety strap on, but shift its position with the hands before each step is taken.

c. *Special Precautions When There are Two or More Workmen on One Pole*

Be sure each operation is planned so that each person knows what the other intends to do and when he will do it.

Plan the job so as to avoid working directly above or below another workman on the same pole.

Stop work and watch the other person when he is shifting position.

5.1.6.5 *Procedure for Descending the Pole*

Disengage the safety strap by reversing the procedure of paragraph 5.1.6.3.

On reaching the ground, be absolutely sure of the balance before removing the hands.

5.2 PREVENTIVE MAINTENANCE

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment to eliminate major breakdowns, unwanted interruption in service, and to keep the equipment operating at top efficiency. The prime function of preventive maintenance is to prevent breakdowns, and therefore, the need for repair.

A through inspection together with splicing, terminating, and emergency procedures comprise the maintenance requirements for the transmission lines. The performance of these routines keeps the lines in good condition and ensures reliable service.

5.2.1 Schedule

Routine intervals on the communication-system components are listed in the Master Maintenance Schedule of MG-102, *Plant Operating and Maintenance Procedures.*

5.2.2 Methods

5.2.2.1 *Open Wire Lines*

a. *General Inspection*

Inspect the transmission line for cuts, nicks, breaks, and broken insulators. Inspect the line for proper mounting to the pole. Inspect the line for cleanliness of insulators and looseness of connections. Inspect pole guys for proper tension.

Tighten all loose connections and loose guys. Clean the insulators using a clean cloth and cleaning solvent.

b. *Emergency Operation*

When necessary to improvise cabling for emergency operation, remember the following general rules:

(1) The impedance of the line must match the impedance of the load as nearly as possible.

(2) Be sure all connections are clean and tight.

5.2.2.2 *Coaxial Cable (Solid Dielectric)*

a. *General Inspection*

(1) *Mechanical Inspection:* Using binoculars as available, visually inspect all readily-accessible cables, connectors, plugs, jacks, and receptacles for defects. Coordinate this inspection with other outside plant inspections.

(2) *Cleaning:* The following tools and materials are required for cleaning:

(a) Cleaning solvent (Vythene)

(b) Pump, compressor-vacuum system

(c) Brushes, soft

Use a soft brush and keep all accessible cables and connectors free of dust and foreign matter. Avoid the use of cleaning solvents unless absolutely necessary. Most solvents are destructive to synthetic materials such as rubber and plastics, and are harmful to the skin, eyes, and lungs. The safest of the cleaning solvents is Vythene which is a stabilized trichloroethylene. It is not flammable or explosive when used under normal conditions. It will dissolve oils, fats, grease, and tars and does not leave a residue. If Vythene is not available, trichloroethylene may be used.

Use a vacuum hose for cleaning connectors, receptacles, plugs, and jacks not easily cleaned with a brush.

b. *Aerial Coaxial Line Inspection*

(1) *General:* The solid-dielectric coaxial cables are used to transmit rf energy between the antennas and the transmitting and receiving equipment in the buildings. Some of the aerial runs may be several thousand feet in length. Weather conditions must largely determine the frequency of required inspections. Aerial cables must always be inspected immediately following storms and high winds. Regular periodic inspections must be made at least every month to ensure that the lines are maintained and in good working condition.

CAUTION

Wind storms may break or dislodge poles from their anchorage. Coordinate their inspection with other outside-plant inspections.

(2) *Coaxial Cable Inspection:* Check the jacket for damage and distortion or signs of deterioration.

Check the cable for short kinks or bends exceeding the minimum bending radius.

Check the coaxial cable supporting clamps on poles, towers, and supporting cables to see that they are in place and have not chafed the coaxial cable.

Check the wraplock that secures the coaxial cable to tower or poles and see that it and the cable have not been damaged.

Check all junction cable connectors and see that they are tight and not damaged.

Feel the cable while in operation to determine if it is heating excessively.

(3) *Supporting Cable Inspection:* Check the supporting cable for excessive sagging and tighten it if necessary.

Check the suspension bolts, suspension clamps, guy bolts, guy straps, thimble-eye nuts, and strandvises to see that they are in their respective normal positions.

c. *Buried Coaxial Line Inspection*

Inspect all connections at terminal ends of buried cables and the connections in junction or splice boxes, wherever used.

Check the grade covering above buried cables to see that it has not been damaged by heavy mobile equipment.

d. *Coaxial Connector Inspection*

Check all cable connections to see that they are secure and that improper connectors have not been used.

Check the armor for damage. If damaged armor cannot be repaired, the cable must be replaced. The function of the armor is to protect the cable from physical damage.

Check the jacket where it enters the connector and make sure it is not chafed or damaged.

Feel the cable and connector while in operation. Excessive heat indicates excessive power loss caused by standing waves introduced as a result of using the wrong connector or not matching the impedance of the load with that of the line.

e. *Emergency Operation*

Where necessary to improvise cabling for emergency operation, remember the following general rules.

The impedance of the line must match the impedance of the load as nearly as possible.

Choose only couplings designed for a specific size and type of coaxial cable.

See that all terminations and splicings are made as described in the appropriate drawing.

5.2.2.3 *Heliax Cable*

a. *General Inspection*

(1) *Mechanical Inspection:* The following tools and equipment are required for inspecting cables:

Binoculars—Visually inspect all readily-accessible cables, connectors, adapters, plugs, jacks, and receptacles for defects. Coordinate this inspection with other outside plant inspection.

(2) *Cleaning:* The following tools and materials are required for cleaning:

(a) Brushes, soft

(b) Pump, compressor-vacuum system

(c) Cleaning solvent (vythene)

(3) *Procedure:* Use a soft brush and the vacuum hose to keep all accessible cables and connectors free of dust and foreign matter.

Avoid the use of cleaning solvents unless absolutely necessary. Most solvents are destructive to synthetic materials such as rubber and plastics, and are harmful to the skin, eyes, and lungs. The safest of the cleaning solvents is Vythene. It is not flammable or explosive when used under normal conditions. It dissolves oils, fats, grease, and tars, and does not leave a residue. If Vythene is not available, trichloroethylene may be used.

Use a vacuum hose for cleaning connectors, adapters, receptacles, plugs, and jacks not easily cleaned with a brush.

b. *Aerial Heliax Cable Inspection*

The air-dielectric coaxial cables described in this instruction are used to transmit rf energy between the antennas and the transmitting and receiving equipment. Weather conditions must largely determine the frequency of required inspections. Aerial cables must always be inspected immediately following high winds. Regular periodic inspections must be made to ensure that the lines are in good condition.

(1) *Cable Inspection:* The following tools and equipment are required:

(a) Belt, body

(b) Strap, safety

(c) Binoculars

NOTE

This inspection is made from the ground, whenever possible

Check the vinyl jacket for any signs of kinks, cracks, or deterioration, especially at bends and at connectors.

Check the cable for kinks or short bends exceeding the minimum bending radius as given in Table II.

Check the Heliax cable's supporting clamps on poles, towers, and supporting cables to see that they are in place and have not chaffed the cable.

(2) Procedure: Check the wraplock that secures the heliax cable to the tower or poles and see that neither the wraplock nor the cable have been damaged.

Check all junction cable connectors to see that they are tight, and that the cable and connectors are not damaged.

Feel the cable while in operation to determine if it is heating as a result of excessive standing waves. Inspect the pressure in all spare reels of cables. If the cable has lost pressure, check the end seals with soap bubble solution. The pressure must be at least 5 pounds per square inch.

c. *Buried Heliax Cable Inspection*

(1) Procedure: Inspect all connections at terminal ends of buried cables and in junction or splice boxes, wherever used.

(2) Check the condition of the polyethylene jacket which is placed over the outer conductor on Heliax cables. It must be examined carefully for cracks, splits, or any signs of deterioration. Also, check its condition in all junction and splice boxes, wherever, used.

Check the grade covering above buried cables to see that it has not been disturbed by heavy mobile equipment.

d. *Coaxial Connector Inspection*

Check all cable connectors to see that they are secure, and that improper connectors have not been used. Check the vinyl jacket for cracks, deterioration, or damage. If the jacket is damaged, repair with insulating varnish and synthetic-resin tape. The jacket protects the outer conductor. Check carefully for indications of deterioration of the jacket or sheath. Check the cables, especially where they enter the connectors, and see that they are not damaged. Feel the cable and connector while in operation. Excessive heat indicates excessive power loss caused by standing waves introduced as a result of a defective or incorrect connector, or not matching the impedance of the load with that of the line.

e. *Emergency Operation*

Where necessary to improvise cabling for emergency operation, remember the following general rules. The impedance of the line must match the impedance of the load as nearly as possible.

Choose only couplings and connectors designed for a specific size and type of coaxial cable.

5.3 TESTS

5.3.1 DC Continuity Tests

A dc continuity test of the rhombic receiving antenna system can be made with an ohmmeter from the receiver end of the RG-8A/U cable. Refer to the schematic diagram of the balun, Figure 1-16, and Figure 4-1, Receiving-Antenna System. The ohmmeter will record essentially the terminating resistor RL, 600 ohms.

Ohmmeter tests for opens and grounds can be made on all transmission lines. In some cases, it may be necessary to disconnect the lines from associated equipment. The technician must refer to equipment drawings to determine this before making the tests.

5.3.2 Gas Pressure Test (Heliax Cable)

Check to see if the line remains pressurized to 5-10 pounds per square inch (psi). Check the system for leakage at 20 psi. With the manifold valves closed, the pressure drop in the line should be less than 2 psi in 24 hours.

NOTE

Tap the pressure gauge case gently before taking readings to make sure the needle is not stuck.

If a larger pressure drop is noted, refer to paragraph 5.4.3.3 for corrective action.

5.4 CORRECTIVE MAINTENANCE

5.4.1 General Information

Corrective maintenance of the transmission system consists of repairing broken open wire lines, replacing and splicing coaxial cables, and replacement of baluns and coaxitrons.

5.4.2 Open Wire Lines

Repairs to the open wire transmission line and exponential line consists mainly of repairing broken wires. See drawing DP-11234 for splicing methods. Paragraph 5.3 of Part III, which gives corrective maintenance procedures for rhombic antennas, also applies to wires, poles, and guys of the open wire transmission lines. Burns and Roe drawings S-4011 and S-4013 give detailed specifications for poles, guys, and associated hardware.

5.4.3 Coaxial Cables

5.4.3.1. *General*

In most instances, defective coaxial cable can be remedied by splicing in a good piece of cable in place of the defective section. The drawings listed in paragraph 5.8 give details on how to splice and terminate coaxial cables.

5.4.3.2 *Disassembly and Reassembly*

Cable ends, after being disconnected from associated cable or equipment, must be protected by placing a waterproof wrapper over the end of the cable to prevent dirt and moisture from entering the cable.

Cables must first be temporarily tied firmly to the pole or at least before any of the supporting cable clamps are removed. Care must be exercised when lowering and raising the cable to prevent kinks.

5.4.3.3 *Locating Leaks in Transmission Lines*

Increase the line pressure to 30 pounds-per-square-inch (psi) and apply a thin soap solution to all flange joints and air fittings to find the leak. The presence of bubbles indicates a leak.

To fix leaks that occur at flange joints, remove bolts and separate flanges. Discard O ring and clean both flange faces thoroughly. Check for nicks or gouges in the flange faces; and if necessary, burnish with fine-emery cloth. Clean a new O ring and apply a thin coating of silicone grease. Place O ring in groove, insert inner connector, and reconnect flanges. Make sure that O ring is slated properly in groove before tightening bolts.

To fix leaks at gas fittings, replace defective parts; or if leak is around threads, remove fitting and clean threads. Replace fitting and tighten after coating threads with pipe dope.

Pressure test the line after leaks have been repaired. Pressurize the line to 20 psi and close the manifold valves. Pressure loss should not be more than 2 psi in 24 hours. Purge the line by following instructions in paragraph 5.4.3.4. Repressurize the line to 10 psi.

5.4.3.4 *Purging Air Dielectric Transmission Lines*

The purpose of this procedure is to provide the method for purging the transmission line. Purging the line is necessary to remove any moisture that may be present in the line. This must be performed upon installation of a new line and repair or opening of the line.

Purge the line as follows:

Pressurize the line to 30 pounds per-square-inch (psi). Close the manifold valves; and after about 15 minutes, release the pressure by opening the purge vent located at the gas seal at the out end (antenna) of the line. Close the vent and repressurize the line to 20 psi. This step is important since all moist air in the line must be removed.

Check the system for gas leakage at 20 psi. With the manifold valves closed, the pressure loss in the line must be less than 2 psi in 24 hours. If a larger pressure drop is noted, refer to paragraph 5.4.3.3 for locating leaks.

NOTE

> Tap the pressure gauge case gently before taking readings, to make sure the needle is not stuck.
>
> Adjust regulator and line pressure to 10 psi. This is a satisfactory operating pressure.

5.4.4 Bahms and Coaxitrons

5.4.4.1 *Disassembly*

Disconnect the antenna leads from the bahm or coaxitron by removing the nuts of the stud terminals.

Tape the loose antenna leads to a firm support with friction tape.

Disconnect the coaxial cable from the unit at the coaxial fitting.

Place a waterproof wrapper over the coaxial cable end, and tie the cable to the pole or mast with a rope, if necessary, to prevent kinking.

Remove the unit from the pole, or supporting structure, by removing the lag bolts from the mounting bracket. Tie a rope around the case and lower the defective unit to the ground.

5.4.4.2 *Reassembly*

Raise the unit to the pole, or mast, using a rope. Mount the transformer to the pole by replacing the mounting-bracket lag bolts.

Remove the waterproof wrapper from the cable end, and remove the rope holding the cable end.

Connect the coaxial cable to the coaxial fitting on the unit.

Untape the antenna leads and connect them to the unit by replacing the nuts on the stud terminals.

5.4.5 Coaxial Patch Panel Interlock Switch

Panel switch must be closed only when link is fully seated and locked in place. To readjust patch-link actuator, loosen locking nut and reset as required to trip panel switch when link is locked in place.

To correct faulty panel switch operation, check setting shown in Figure 5-4, and replace switch or actuator assembly as required.

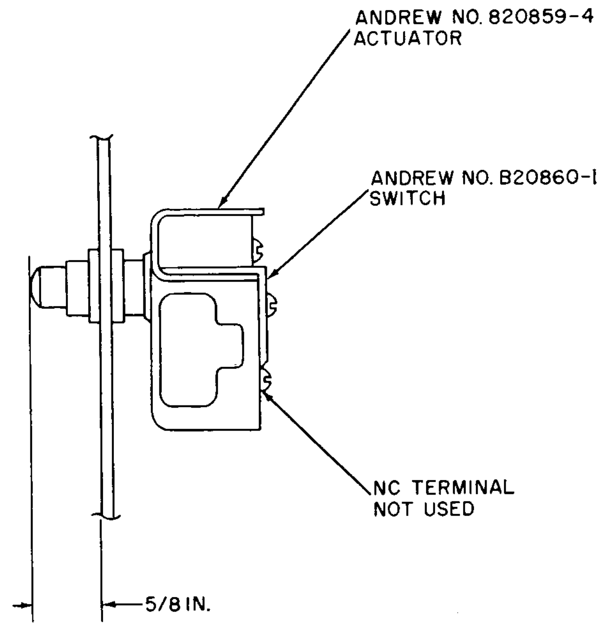


FIGURE 5-4. PANEL SWITCH ASSEMBLY

5.5 TOOLS AND MATERIAL LIST

The following is an index of required tools and material:

a. Body belt

b. Safety strap

c. Safety glasses

d. Hand line

e. Snatch block

f. Block, double rope

g. Binoculars

h. Pump, compressor-vacuum system

i. Brushes, soft

j. Flashlights

k. Kit, hand tools

l. Cleaning solvent

5.6 TEST EQUIPMENT LIST

The following is an index of test equipment.

5.7 DRAWING INDEX

Paragraphs 1.2 and 1.4 of this part describe the major components used in connection with the transmission lines.

Test Equipment	*Purpose*
VHF Admittance Bridge, Model B-801	To measure impedance of transmission lines, baluns, dissipators, and antenna systems.
RF Detector, GPR-90 Communications receiver	To function as an rf detector for the rf bridge, above.
Volt-Ohmmeter, Triplett, Model 630	To measure ac/dc voltage, resistance and current of various components associated with all radio system equipment.
VTVM, Hewlett-Packard, Model 410B	To measure critical ac/dc voltages and resistances on radio system components.
VTVM, Hewlett-Packard, Model 400D	To measure critical low level ac voltages.
Audio Oscillator, Hewlett-Packard, Model 200 CD	To generate audio frequencies in connection with response measurement and adjustment of various components.
RF Signal Generator, Hewlett-Packard, Model 606A	To generate rf frequencies in connection with antenna impedance measurements.
Oscilloscope, Hewlett-Packard, Model 130B	To measure and observe critical ac voltage and waveforms on various radio components.

5.8.1 Western Electric Company Drawings

	Atlantic Ship	*Kano*	*Zanzibar*	*Indian Ocean Ship*
a. Index of Job Drawings	T-6G03-000	T-6G05-000	T-6G06-000	T-6G07-000
b. System Functional Diagram	T-6G03-1	T-6G05-1	T-6G06-1	T-6G07-1
c. Site Equipment, Block Diagram, Ground Radio and TTY	T-6G03-17	T-6G05-17	T-6G06-17	T-6G07-17
d. Site Equipment, Block Diagram, Power Distribution, Communications, Control, Transmitter Areas	T-6G03-21	T-6G05-21	T-6G06-21	T-6G07-21
e. Site Equipment, Block Diagram, Power Distribution Point-to-Point Transmitter Areas	T-6G03-24	T-6G05-24	T-6G06-24	T-6G07-24
f. Floor Plan HF Radio and Telemetry Room, Instrumentation Area (Strip Control Area)	T-6G03-101	T-6G05-101	T-6G06-101	T-6G07-101

		Atlantic Ship	*Kano*	*Zanzibar*	*Indian Ocean Ship*
g.	Floor Plan HF Radio Transmitting Room ('Tween Deck Area on Ship Sites)	T-6G03-102	T-6G05-102	T-6G06-102	T-6G07-102
h.	Floor Plan-Control Area		T-6G05-103	T-6G06-103	
i.	Wiring List (HF)	T-6G03-1830	T-6G05-1830	T-6G06-1830	T-6G07-1830
j.	Relay Rack and Front Equipment Drawings (HF)	T-6G03-183	T-6G05-183	T-6G06-183	T-6G07-183
k.	Relay Rack Equipment-Receiver Building	T-6G03-138	T-6G05-138	T-6G06-138	T-6G07-138
l.	Relay Rack Equipment-Transmitter Building	T-6G03-139	T-6G05-139	T-6G06-139	T-6G07-139
m.	Details for Assembly of PT450 UHF Antenna and Coaxial Cable Connections			T-6G06-384	
n.	Coaxial Cable Plan and Termination at Transmitter Building		T-6G05-385	T-6G06-385	
o.	Facility Layout, Point-To-Point Ground Communications			T-6G06-386	
p.	DP-10025—Method of Terminating Coaxial Cable				
q.	DP-10367—Method of Terminating Solid-Dielectric Coaxial Cable				
r.	DP-11189—Method of Terminating Cables and Details for Point-To-Point Transmitter and Receiver Building				
s.	Rhombic Antennas For Kano and Zanzimar				
t.	Rhombic Transmitting or Receiving Antenna RTA-330 for Steel Pole Mounting with Transmission Line RTL-300.				
u.	DP-11217—Interconnections, GPT-10K Transmitter.				
v.	Equipment Specification, Material and Installing Information for High Frequency and Ultra-High Frequency (Zanzibar only) and associated Multiplexing equipment	43003-183	43005-183	43006-183	43007-183
w.	Equipment Specifications Material and Installing Information for Outside Plant Installation.	43003-284	43005-284	43006-284	43007-284

5.8.2 Burns and Roe Drawings

	Atlantic Ship	Kano	Zanzibar	Indian Ocean Ship
a. Isometric Wiring Diagram Point-To-Point Transmitter and Receiver Antennas	PS-3105			PS-3105
b. Antenna Outboard Profile and General Arrangement Plan	PS-4101			PS-4101
c. Point-To-Point Receiving and Transmitting Antennas	PS-4111			PS-4111
d. Site Plan, Receiver Installation Area		5-4101	6-4101	
e. Site Plan, Transmitter Installation Area		5-4103	6-4103	
f. Power Lighting and Grounding Plant Point-To-Point Transmitter Building		S-3070	S-3070	
g. Power Lighting Cable Ladders and Grounding Plans Point to Point Receiver Building		S-3080	S-3080	
h. Rhombic Antenna Supports		S-4011	S-4011	
i. Rhombic Antenna Transmission Line Supports		S-4013	S-4013	

PART III

SECTION 1. DESCRIPTION

1.1 GENERAL INFORMATION

This section describes the rhombic antennas at Kano and Zanzibar and the log periodic antennas at Zanzibar used for hf radio point-to-point communications, and the uhf paraflector antenna used at Zanzibar for intrasite communications.

1.1.1 Scope of Part III

This part includes component description, test, and maintenance information for the antennas. Diagrams showing the antennas used at the two land sites are included in this section.

1.1.2 System Function

The antennas described in this section are used to radiate and receive hf radio energy at Kano and Zanzibar for point-to-point communications and also for uhf intrasite communication at Zanzibar. Table I lists the number of antennas in use at the land sites.

1.1.3 System Characteristics

The radio antennas used in this Mercury application are designed to operate over a wide frequency band, such as 7-28 mc, or in one band, such as the 450-470 mc uhf band. The rhombic antennas and the log periodic antennas are broad-band antennas that can be used on a number of operating frequencies within the 7-28 mc band. The uhf paraflector antenna is factory tuned to the specified operating frequency.

1.2 PHYSICAL DESCRIPTION

1.2.1 Rhombic Antenna

The transmitting and receiving rhombic antennas are Model RTA-330, type A, manufactured by Wind Turbine Company. They consist of a 3-wire curtain supported by four 8-inch OD steel poles. The poles are provided with steps to aid in installation and maintenance. Figure 1-1 shows the rhombic antenna. Type A is used for distances of 3,000 miles and

TABLE I

NUMBER OF ANTENNA USED

	KANO		*ZANZIBAR*	
	No.	*Path*	*No.*	*Path*
Rhombic, Transmitting	2	London	2	Kano
	2	Zanzibar		
Rhombic, Receiving	2	London	2	Kano
	2	Zanzibar		
Log Periodic, Transmitting			1	IOS
Log Periodic, Receiving			2	IOS
UHF Paraflector			2	Intrasite

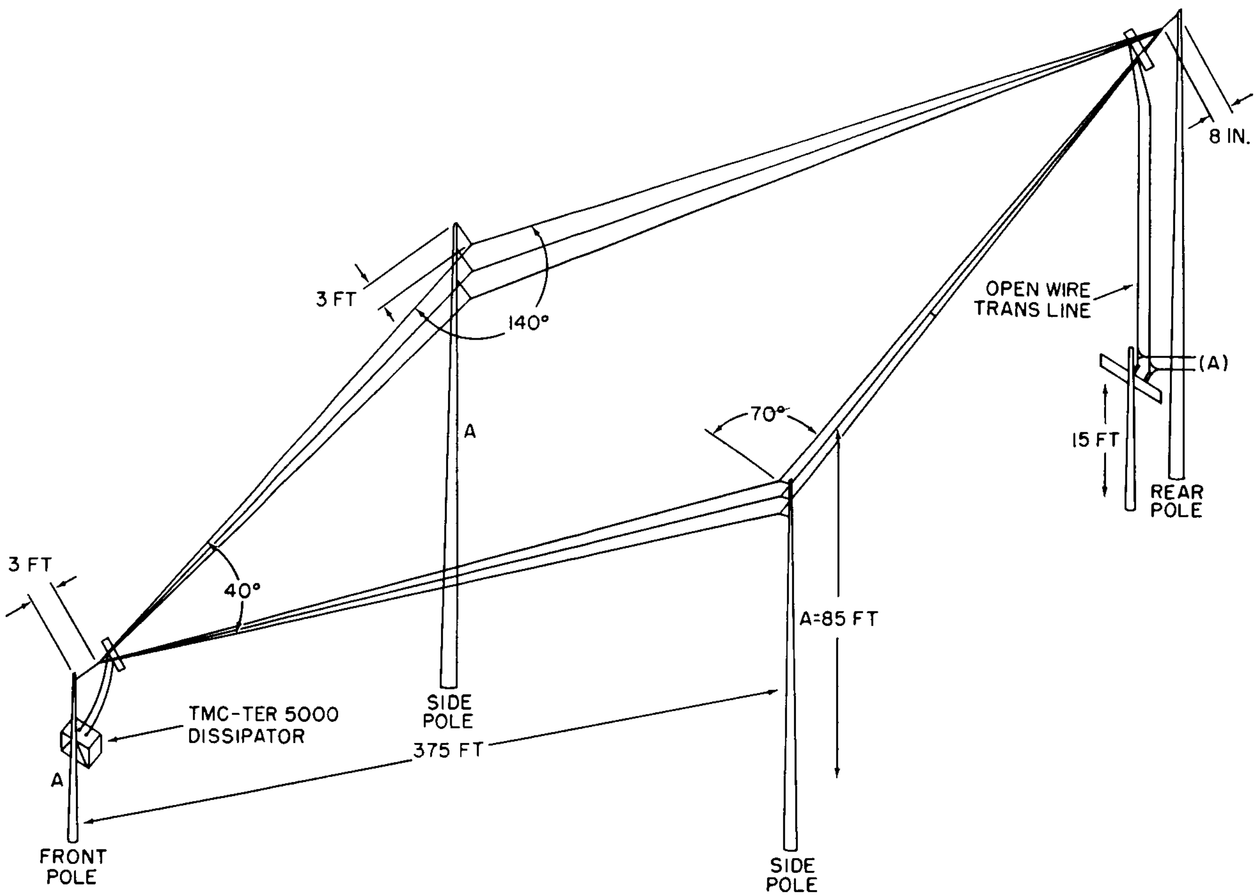


FIGURE 1-1. TYPE A RHOMBIC ANTENNA

greater. Each side of the antenna is 375 feet long. The side poles are 262.4 feet apart. The tilt angle (∅) is 70 degrees. The average height above ground level is 65 feet, with the harness attachment 67 feet above ground. A TER—5,000 (600 ohm) dissipator is mounted on the front pole of the transmitting rhombic and connected to the rhombic as shown. A receiving rhombic uses a RTB-5 (600-ohm) rhombic terminal unit as the termination. An open-wire transmission line feeds the transmitting antennas. In the receiving rhombic, a RAC-7A balun is mounted on the rear pole and is a matching device between the 600-ohm antenna and the 50-ohm heliax cable.

1.2.2. Log Periodic Antenna

The LPA-728/A log-periodic antenna is a unidirectional, broadband, steerable antenna designed to operate from 7 mc to 28 mc. The use of off-set straight elements as a logarithmical periodic antenna structure is an innovation which gives mechanical and electrical characteristics. The characteristic impedance of this antenna is approximately 135 ohms. This impedance is transformed to 50 ohms by a stepped exponential line, which is approximately 40 feet long. An electrical rotator and control panel permit continuous rotation at a speed of 1/2 rpm. This antenna is shown in Figure 1-2. The over-all height above ground is 105 feet, with a steel support tower height of 60 feet. The over-all width is 95 feet.

The antenna system consists of the following:

a. Antenna proper

b. Impedance matching transformer, transmission line, and rotary joint

c. Azimuth rotator

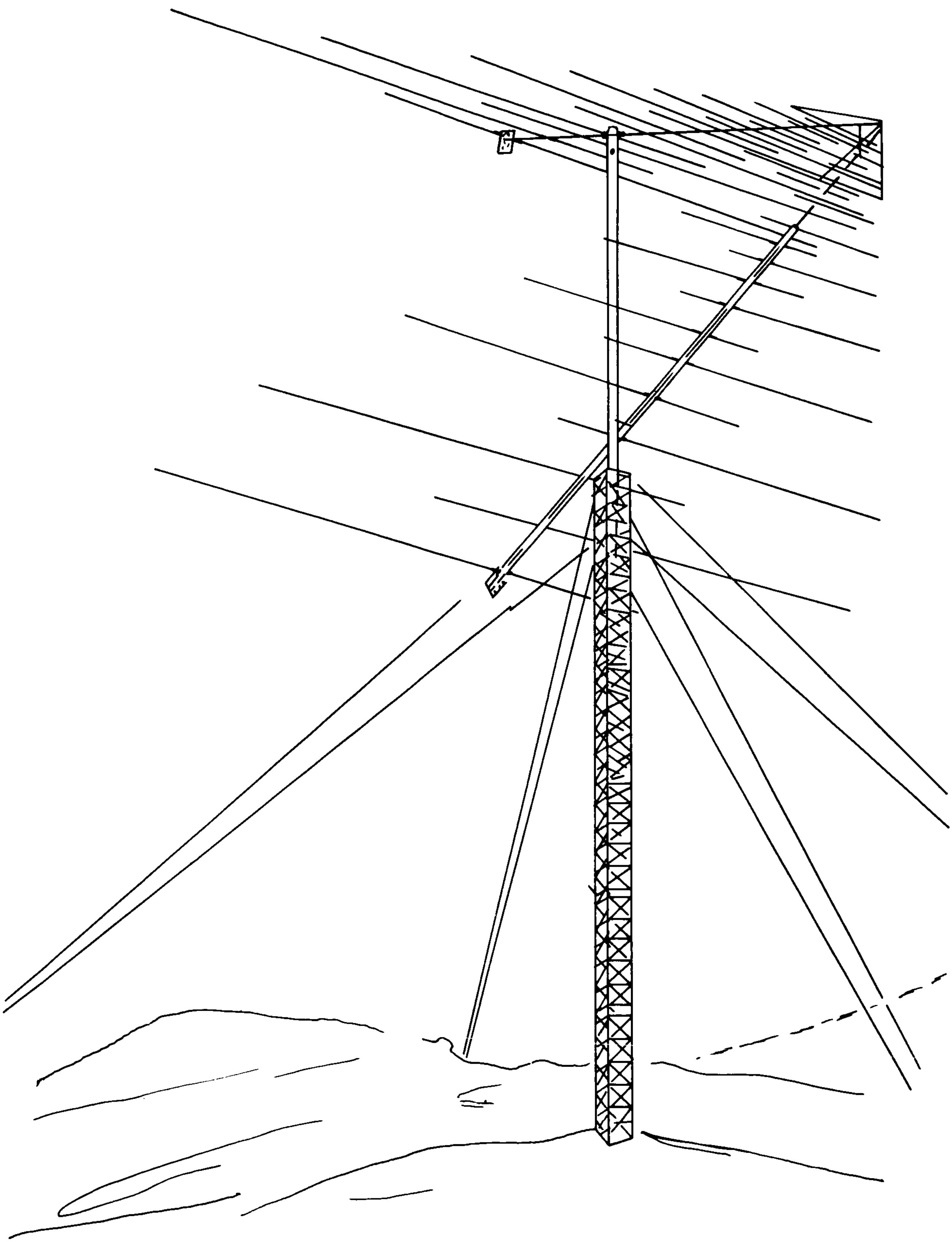


FIGURE 1-2. LOG-PERIODIC ANTENNA (LPA 728-A)

d. Control panel and cables

e. Sixty-foot support tower with guying hardware.

This antenna has a gain of 6.8 db over an isotropic antenna, horizontally polarized with a half power lobe width of approximately 60 degrees. The power handling capability is 10 kw average, with a front-to-back ratio of greater than 15 db.

The rotational mechanism consists of an azimuth rotator. This rotator is a heavy duty, double reduction, worm gear unit which provides self-locking when the rotator is not being rotated. The rotator is designed to provide continuous rotation in winds of 40 mph or less, and survival in winds of 90 mph. The azimuth rotator is located inside the main supporting tower and directly connected to the antenna mast. The shaft is retained by two heavy-duty bearings. One mounts on the tower head plate and the other mounts to a bearing plate 7 feet below the tower head plate. The rotator parts which are subject to damage due to weather exposure, have been covered to provide long life and low maintenance. The rotation motor is a special, instantly reversible, capacity start, single-phase motor. A synchro-transmitter transmits azimuth information to the control panel azimuth indicator. A nonlocking double-throw toggle switch mounted on the control panel can be thrown to either the clockwise (CW) or counter-clockwise (CCW) position to rotate the antenna.

1.2.3 UHF Paraflector Antenna, PR 450

The uhf antenna is made by Scala Radio Company and is shown in Figure 1-3. It is mounted on a 2-inch steel pipe for horizontal polarity. It is 36 inches wide and 67 inches high. The only critical part of the whole antenna is the driver element, which is tuned to the specified frequency at the factory.

1.3 FUNCTIONAL DESCRIPTION

1.3.1 Rhombic Antenna

A single rhombic transmitting antenna is used to radiate power. A second rhombic transmitting antenna is provided so that the spare transmitter can be tuned up to a different frequency. Zanzibar has two antennas oriented toward Kano. Kano has two antennas toward London and two toward Zanzibar.

Two rhombic receiving antennas are arranged for space diversity. Space diversity technique takes advantage of the fact that signals received at different locations do not fade synchronously. If the antennas are spaced 3 to 10 wavelengths apart, the signal received at each antenna must fade independently.

1.3.2 Log Periodic Antenna

Three steerable log-periodic antennas, one transmitting and two receiving, are provided at Zanzibar for emergency communication with the Indian Ocean ship. The receiving antennas are arranged for space diversity like the rhombic receiving antennas.

1.3.3 UHF Paraflector Antenna

Two uhf antennas are used at Zanzibar, one at the hf transmitter location, and one at the hf receiver location, for intrasite communication. A common antenna is used for both directions of transmission through the use of a diplexer which connects to both the uhf transmitter and receiver.

1.4 EQUIPMENT SUPPLIED OTHER THAN ANTENNAS

1.4.1 Index

a. Transmitting dissipator TER-5000(600)

b. Transmitter dummy load TER-5000 (70)

c. Rhombic terminal unit RTB-5

1.4.2 Description and Use

1.4.2.1 *Transmitting Dissipator TER-5000(600)*

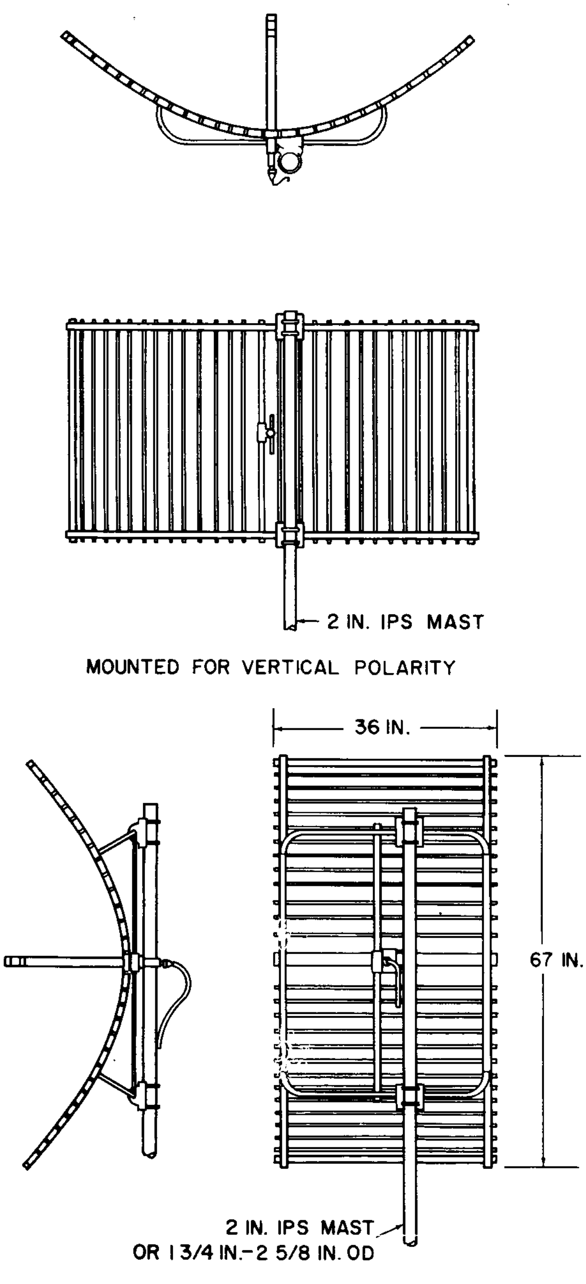


FIGURE 1-3. SCALA PARAFLECTOR ANTENNA, PR 450

This item is used to terminate the rhombic transmitting antennas, and is mounted on the front rhombic pole. It is a resistive termination capable of dissipating rf energy from dc to 30 mc up to 5,000 watts. These dissipators are in a convenient package requiring a minimum of installation and maintenance.

The resistors are a special pyrex-glass blank with a resistive element electrofused in the surface of the glass. A baked silicone protective coating is used. The resistors are mounted in a spring-suspended frame to compensate for thermal expansion. Lightning protection is provided internally by means of spark gaps.

The units are housed in a fibreglass reinforced-plastic case approximately 63 inches high, 24 inches deep, and 46 inches wide. The case provides protection from the elements and is fitted with screened vent ports for proper air circulation. All metals used are nonferrous, insulation is of teflon, and the entire assembly is protected by a silicone spray. Figure 1-4 shows transmitting dissipator TER-5000(600) with the front cover removed. The antenna connection is made at the feed-through insulators on top of the case.

1.4.2.2 *Transmitter Dummy Load TER-5000(70)*

One of these dummy loads is provided at each hf transmitter location and mounted outside the building on a wall of the building. These units are similar to the dissipators described in paragraph 1.4.2.1, except that the impedance is 70 ohms instead of 600 ohms. A coaxial connector is provided, instead of the feed through insulators, for the 1-5/8-inch heliax cable that connects to the coax-patch panel.

1.4.2.3 *Rhombic Terminal Unit RTB-5*

This unit is a 600-ohm termination for the receiving-rhombic antenna. Four 150-ohm plug-in resistors are mounted in a weather-resistant equipment case made of aluminum alloy, measuring 9 x 9 x 5 inches. A spare resistor is also mounted in the case. A built-in lightning arestor prevents the build up of static charges

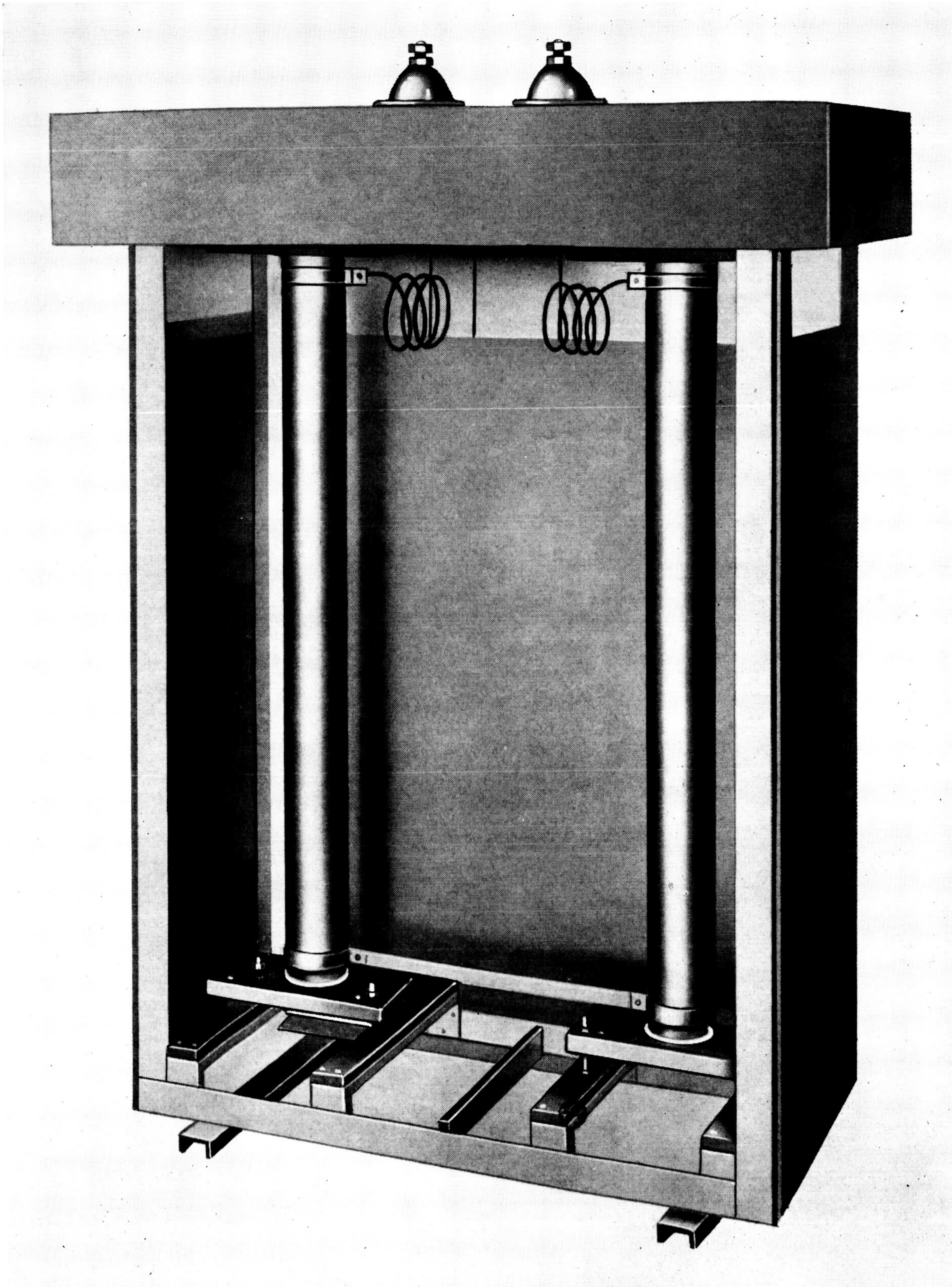


FIGURE 1-4. MODEL TER 5000

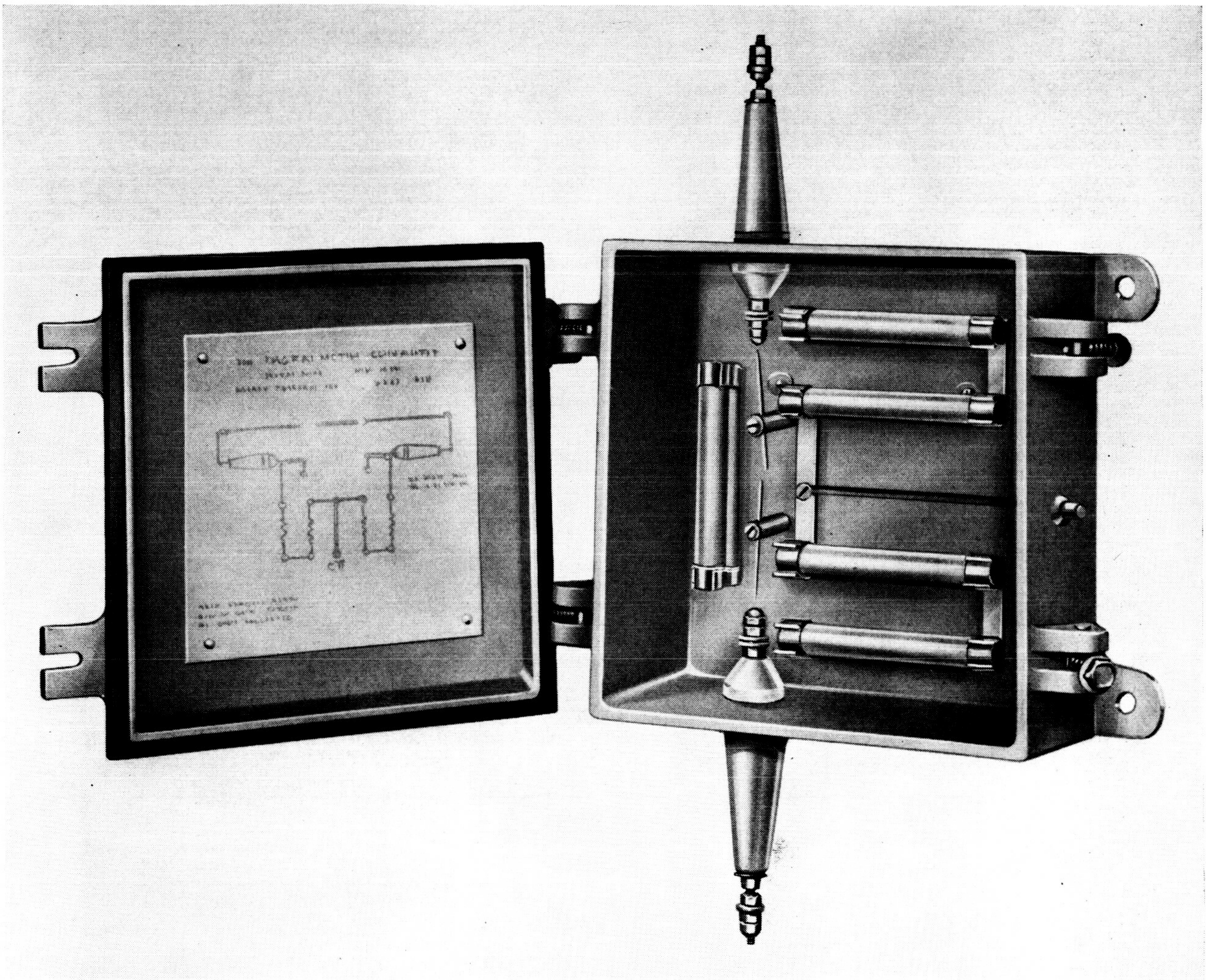


FIGURE 1-5. RHOMBIC-TERMINAL UNIT, MODEL RTB

which might damage associated equipment. A ceramic feed-through insulator on each side of the case provides connections to the antenna. A coaxial ground connection is provided on the bottom of the case. The case is mounted on the front rhombic pole.

Figure 1-5 shows the unit with the lid open. Figure 1-6 is a schematic drawing.

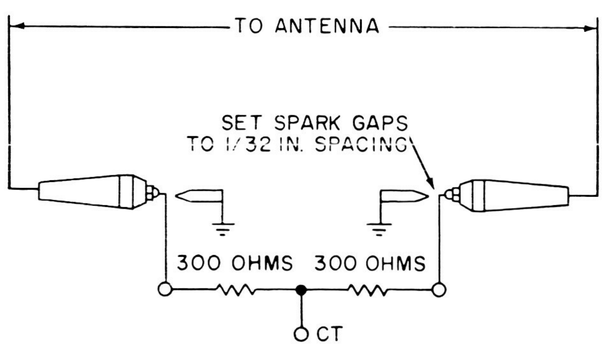


FIGURE 1-6. RHOMBIC-TERMINAL UNIT, MODEL RTB, SCHEMATIC

SECTION 2. INSTALLATION

2.1 GENERAL INFORMATION

The antennas must be installed in accordance with Western Electric equipment specifications—284 for each site. Installation information is contained in Western Electric and Burns and Roe and manufacturers' drawings.

SECTION 3. THEORY OF OPERATION

3.1 GENERAL INFORMATION

The rhombic-antenna system consists of one transmitting antenna and two receiving antennas for one radio path.

The log periodic antennas used at Zanzibar for emergency communication with the Indian Ocean Ship are used like the rhombics, one for transmitting and two for space diversity receiving.

The two uhf paraflector antennas used at Zanzibar for intrasite communication are common for both directions of transmission.

SECTION 4. SYSTEM OPERATION

4.1 RHOMBIC ANTENNAS

The receiving rhombic antennas are used on a space diversity circuit and are connected to the receiving equipment by two 7/8-inch heliax cable. The coaxial cable is coupled to the antenna by a 50-ohm unbalanced to 600-ohm balanced transformer (RAC-7A) balun which is mounted on the rear pole. The receiving antennas have a 600-ohm terminating resistor (RTB-5 rhombic terminal unit) suspended between each side of the antenna curtain on the front poles to give the antenna its unidirectional characteristics.

The transmitting rhombic antenna is fed by a 1-5/8-inch, 50-ohm, heliax-coaxial cable. The cable connects to a 512F-1 coaxitran which is an impedance changing transformer which matches the 50-ohm unbalanced cable to the 200 ohm balanced input of the 512G-1 expotential line. This is an 80 foot tapered 2-wire transmission line, whose output matches the 600-ohm rhombic. The transmitting antenna is provided with dissipator TER-5000(600) which serves for energy dissipation and gives the antenna its unidirectional characteristic. This dissipator is connected between each side of the antenna curtain on the front pole.

4.2 LOG-PERIODIC ANTENNAS

The transmitting antenna is fed by a 1-5/8-inch heliax cable and the receiving antennas are fed The transmitting antenna is fed by a 1-5/8 inch by two 7/8-inch heliax cables. The antennas are rotated by a rotation motor at a speed of 1/2 rpm. A rotary joint permits continuous rotation.

4.3 UHF PARAFLECTOR ANTENNAS

Each of the two uhf terminals, hf receiving area and hf transmitting area, are supplied with one uhf paraflector antenna connected to a 7/8-inch heliax cable transmission line, which in turn is coupled to a diplexer in the equipment cabinet. This antenna system provides the two-way communication between the two areas.

SECTION 5. MAINTENANCE

5.1 POLE CLIMBING AND SAFETY

Paragraph 5.1 of Part II also applies to this section on maintenance of land antennas.

5.2 PREVENTIVE MAINTENANCE

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment, to eliminate major breakdowns and unwanted interruption in service and to keep the equipment operating at top efficiency.

5.2.1 Schedule

Routine intervals on the antenna system are listed in the Master Maintenance Schedule of MG-102, *Plant Operating and Maintenance Procedures.*

5.2.2 Maintenance Methods

5.2.2.1 *General Information*

The maintenance methods used for the hf and uhf point-to-point communication system are described in this part.

5.2.2.2 *Rhombic Antennas*

a. *Special Tools, Apparatus, and Materials*

The following special tools, apparatus, and materials are required to perform the routines outlined in this section:

Item	*Use*
Body belt and safety strap	Used as safety device for pole-climbing personnel.
Block, snatch	Used for hoisting material up poles.
Block, double rope	Used for hoisting material up poles.
Level, hand sighting	Used for sighting in sagging antennas.
No. 10-ZPJ Squeez tool	Used for making wire splices.
No. 12P-1 Squeez sleeves	Used for making wire splices.
Admittance bridge, Model B-801	Used for measuring impedance of transmission line.
Volt-ohmmeter, Triplett 630	Used for checking resistance of splices.

b. Over-All Antenna Installation

Inspect the antenna installation for broken, nicked, or kinked antenna wires and guy wires, and for defective transmission line and dissipation line.

Inspect the antenna installation for broken or leaning poles.

Inspect the antenna installation for broken, cracked, or dirty insulators.

Inspect the antenna installation for improper sagging wires.

c. *Antenna Span*

Inspect the antenna span as follows:

Inspect the antenna span for cuts, nicks, or kinks in the wire.

Inspect the antenna span for broken, cracked, and dirty insulators.

Inspect the antenna span for proper sag as given in Table I.

5.2.2.3 *Log Periodic Antennas*

5.2.2.4 *Over-All Antenna Installation*

Inspect the antenna for bent or missing antenna elements.

Inspect the antenna for bent mast or boom.

Inspect the antenna installation for broken guy wires and defective control cable.

Check the antenna for azimuth rotation by turning the control switch to CW and then to CCW position. The antennas must rotate freely in a clockwise or counter clockwise direction. The antenna-position indicator must be oriented in the same direction as the antenna and must track the antenna's movement.

Lubrication of the rotor mechanism is described in Section 3.6 of ME-719, *LPA728/A Log Periodic Antenna* Instruction book.

5.2.2.5 *UHF Paraflector Antennas*

a. *Over-All Antenna Installation*

Inspect the antenna for bent or missing antenna elements.

Inspect the supporting mast and fittings for proper alignment.

5.3 CORRECTIVE MAINTENANCE

5.3.1 Rhombic Antennas

Corrective maintenance for the rhombic antennas consists of adjustment of the antenna sag, repairing broken antenna wire, and replacement of antenna spans. The manufacturer's installation instructions and Burns and Roe drawings can be used for maintenance work.

5.3.2 Log-Periodic Antennas

Corrective maintenance for the log periodic antenna consists of adjusting guy wire tension, lubrication of the rotor mechanism and replacement of parts as necessary. The manufacturer's instructions for installation can be followed for repair work.

5.3.3 UHF Paraflector Antenna

The only critical part of this antenna is the driver element which can be replaced by following the installation directions.

5.4 TOOLS AND MATERIAL LIST

The following is an index of required tools and material:

a. Body belt

b. Safety strap

c. Safety glasses

d. Hand line

e. Snatch block

f. Block, double-rope

g. Level, hand-sighting

h. Binoculars

i. Brushes, soft

j. Flashlight

k. Cleaning solvent

l. SAE 90 lubricant

m. Grease gun

n. Kit, hand tools

TABLE II

STRINGING SAG AND TENSION DATA, COPPERWELD CONDUCTOR, 3 STRANDS, NO. 12, 40 PER CENT CONDUCTIVITY

Span in Feet	*Sag in Inches*			*Tension in Pounds*		
Span	*30°F*	*60°F*	*90°F*	*30°F*	*60°F*	*90°F*
100	2.3	2.8	3.8	362	288	216
125	3.6	4.5	5.9	360	288	218
150	5.1	6.4	8.4	358	288	221
175	7.1	8.7	11.4	357	288	223
200	9.3	11.4	14.7	355	288	226
225	11.7	14.5	18.1	353	288	228
245	13.9	17.1	21.3	352	288	230
250	14.6	17.9	22.2	352	288	231
270	17.2	20.8	25.9	350	288	233
275	17.8	21.6	26.8	350	288	233
290	19.8	24.0	29.6	349	288	235
300	21.1	25.6	31.4	349	288	236
315	23.4	28.3	34.3	348	288	237
325	24.9	30.1	36.4	347	288	238
350	29.2	35.0	42.0	345	288	241
375	33.8	40.3	48.0	344	288	243
400	38.5	45.6	53.8	342	288	246
425	44.0	51.5	60.0	340	288	248
450	49.7	57.8	67.2	338	288	250
475	55.8	64.5	74.5	335	288	251
500	62.2	71.4	81.8	332	288	252

NOTE

The above tables are based on a 60°F. Stringing tension of 288 lbs, 12.8% of the rated breaking strength of the conductor.

5.5 TEST EQUIPMENT LIST

The test equipment listed in paragraph 5.6 of Part II is also used for antenna work.

5.6 PARTS LIST

The parts list given in paragraph 5.7 of Part II applies to both transmission lines and antennas.

5.7 DRAWING INDEX

The drawings listed in paragraph 5.8 of Part II, transmission lines, also apply to antenna work.

PART IV

SECTION 1. DESCRIPTION

1.1 GENERAL INFORMATION

This section describes the shipboard antennas used for hf radio point-to-point communications for Project Mercury.

1.1.1 Scope of Part IV

This part includes component description, test, and maintenance information for the shipboard antennas.

1.1.2 System Function

The antennas described in this section are used to radiate and receive hf radio energy between the Atlantic ship and New York and the Canary Islands and also between the Indian Ocean ship and Zanzibar and Woomera, Australia.

1.1.3 System Characteristics

The shipboard antennas are designed to operate in the 6-24 mc band. The discone cage transmitting antenna is nondirectional. The vertical-conical receiving antenna is also nondirectional. The horizontal-cage receiving antenna placed between the two masts, has a directional characteristic that offers the best reception at right angles to the length of the antenna. The directional characteristics of all the above antennas will be somewhat altered by the metal mass of the ship. The cage type receiving antenna mounted on booms off the starboard stern is a corner reflector antenna, with the vertical side of the ship and the surface of the water acting as the reflecting surfaces. This antenna is unidirectional. Figures 1-1 and 1-2 show the placement of the shipboard antennas.

1.2 PHYSICAL DESCRIPTION

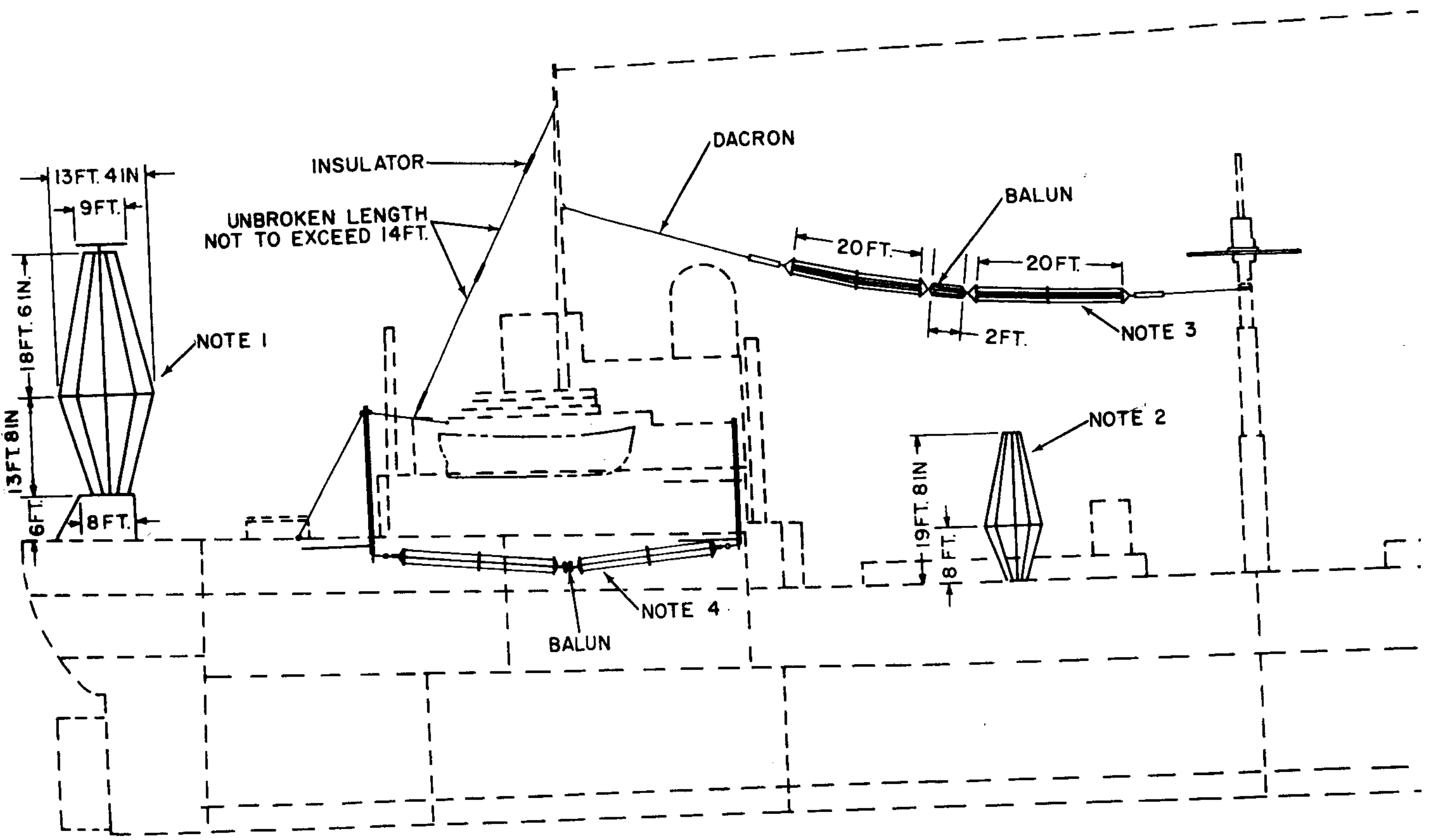
1.2.1 Discone-Cage Transmitting Antenna

A discone cage antenna used for transmitting purposes is located on the bow and stern of the ships. The lower section called a cage antenna, which is designed for the 6-15 mc range, is electrically composed of eight phosphorous-bronze wires strung between the pedestal and the top of the antenna structure. The wires are insulated from the pedestal but are electrically connected at the top. The antenna is exited at the wires near the insulators mentioned above. As the antenna is a broadband antenna, the impedance varies as a function of frequency. In order to minimize the mismatch between the antenna and the heliax transmission line, a network was designed to perform this transformation. It is located below the pedestal of the cage antenna.

The discone antenna, which is designed for the 15-24 mc range, is located at the top of the antenna structure. The eight horizontal radiators and the upper portion of the supporting mast and the eight bronze wires are in essence the discone antenna. This antenna also is broadband in nature and requires a network. This network is a vacuum capacitor in series with the heliax transmission line and is located near the top of the antenna structure in a weatherproof box. This antenna is shown in Figure 1-3.

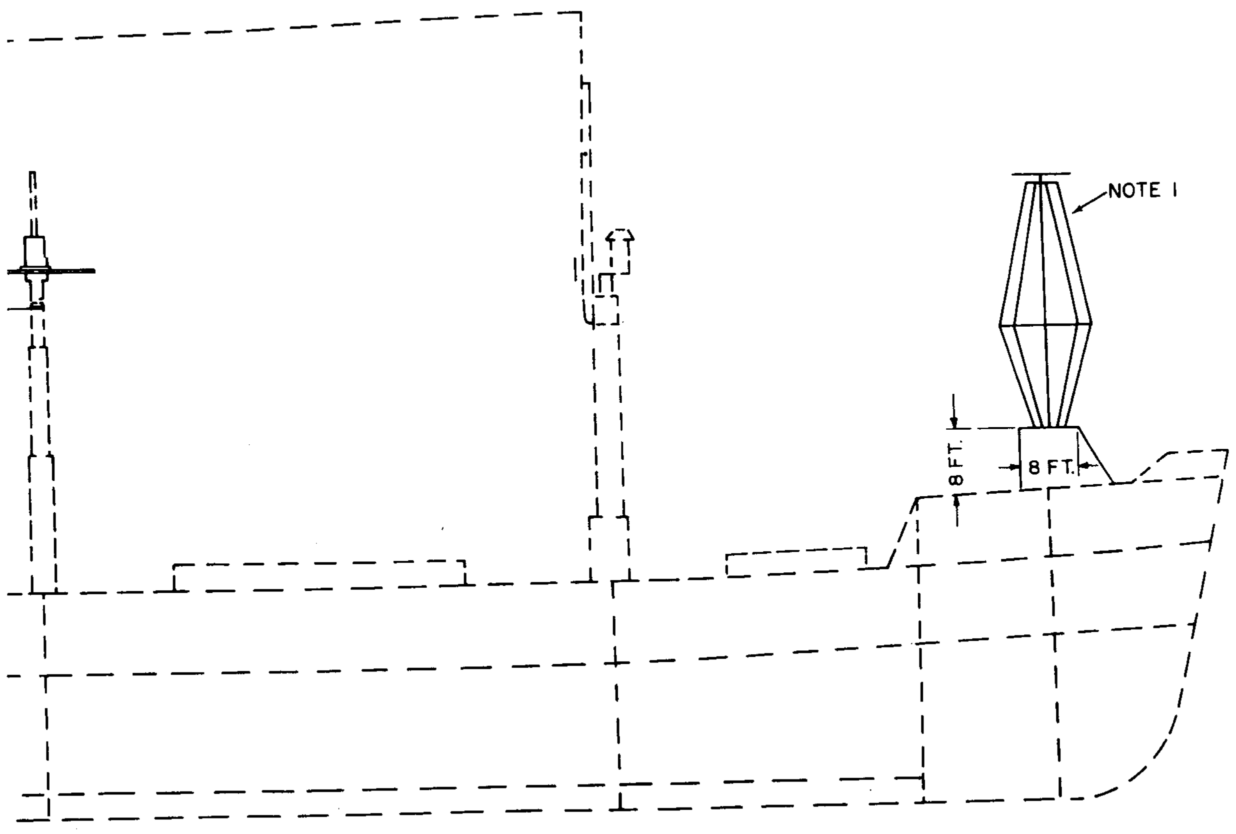
1.2.2 Conical-Monopole Receiving Antenna

The vertical receiving antenna is shown in Figure 1-4. This is a vertical cage-type antenna of eight phosphorous-bronze No. 8 wires approximately 20 feet high and 2 feet wide near the middle. An RG-10A/U coaxial cable is connected to the bottom end of the antenna. This



NOTES:
1-DISCONE/CAGE ANTENNA TRANSMITTING
2-CONICAL MONOPOLE ANTENNA RECEIVING
3-HORIZONTAL CAGE ANTENNA RECEIVING
4-CORNER REFLECTOR ANTENNA RECEIVING

FIGURE 1-1. HF ANTENNA SYSTEM, SIDE VIEW


NOTE 1
8 FT.
8 FT.

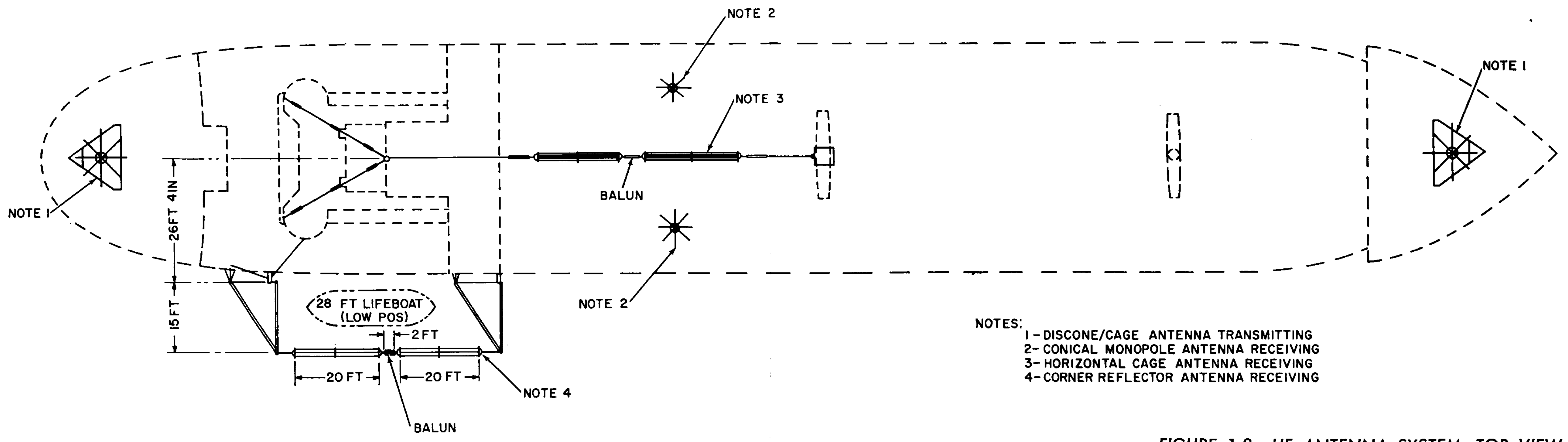


FIGURE 1-2. HF ANTENNA SYSTEM, TOP VIEW

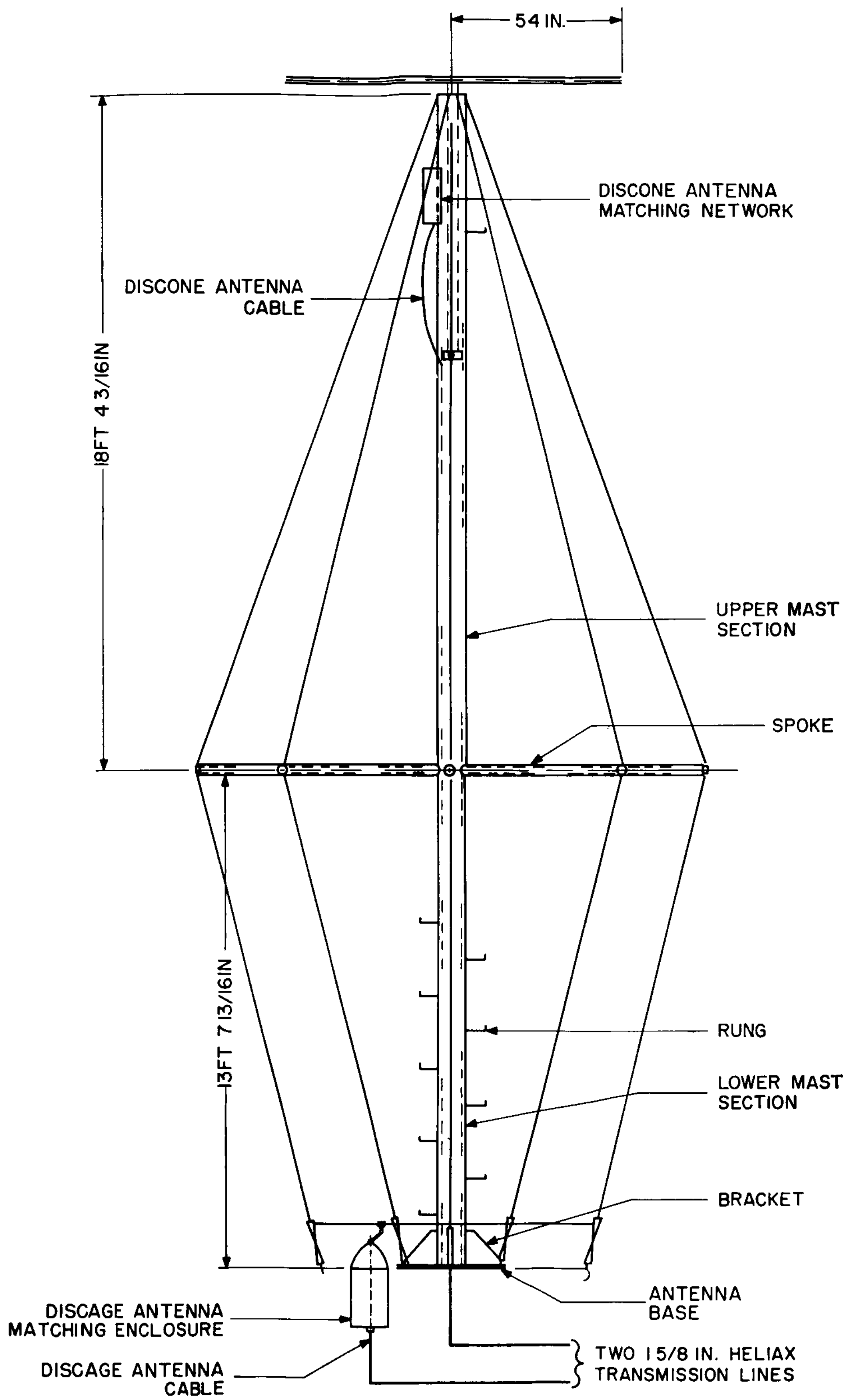


FIGURE 1-3. SHIPBOARD TRANSMITTING ANTENNA

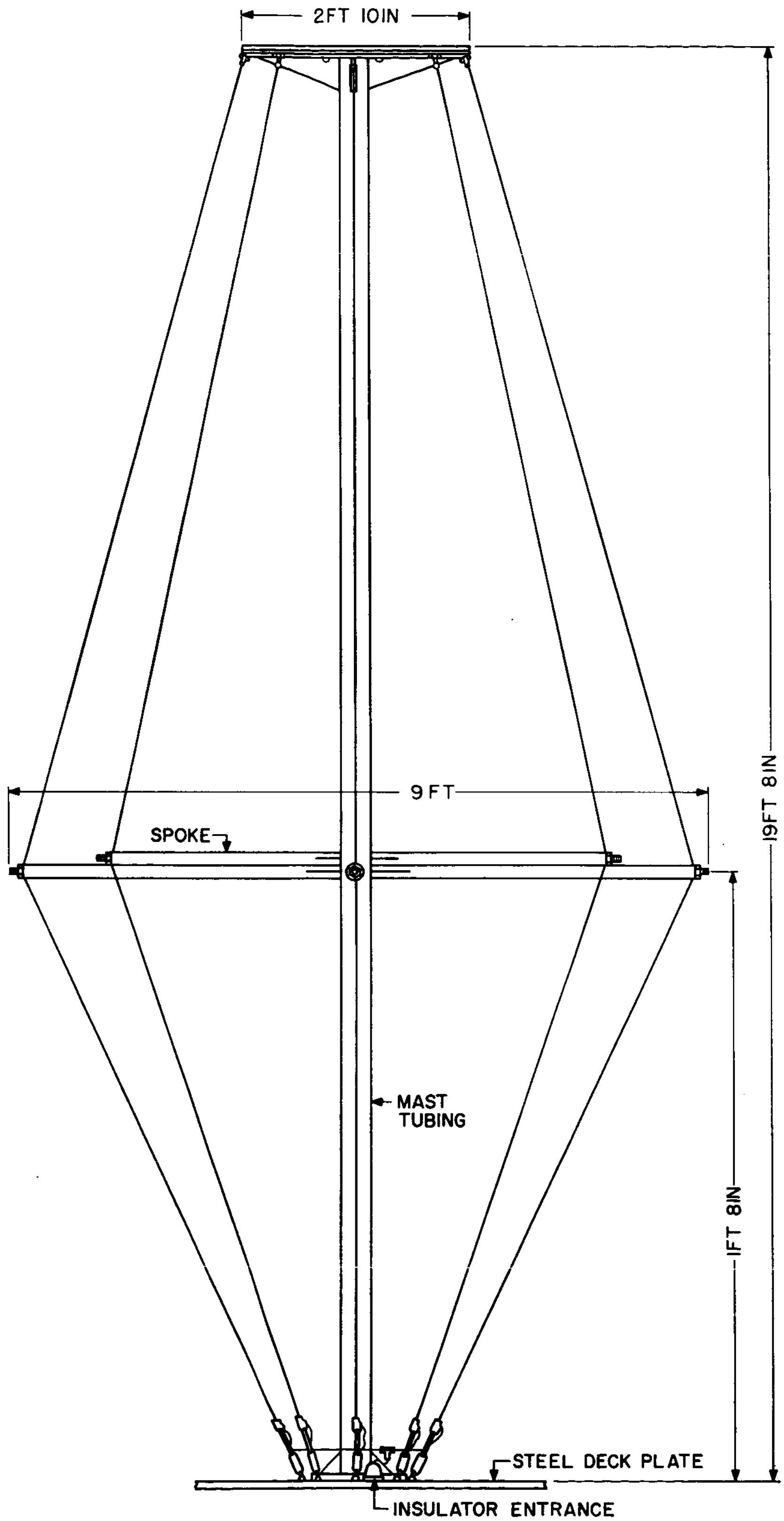


FIGURE 1-4. SHIPBOARD VERTICAL-RECEIVING ANTENNA

vertical receiving antenna is designed to primarily receive vertically polarized signals.

1.2.3 Horizontal-Cage Receiving Antenna

The second half of the polar-diversity receiving antenna system is the horizontal-cage receiving antenna mounted between two masts. This is a dipole type antenna, 42 feet long, fed in the middle by RG-10A/U coaxial cable through a dipole antenna coupler, DAC-8. Each half of this antenna is 20 feet long, with six wires placed to form a cage. This antenna is shown in Figure 1-5.

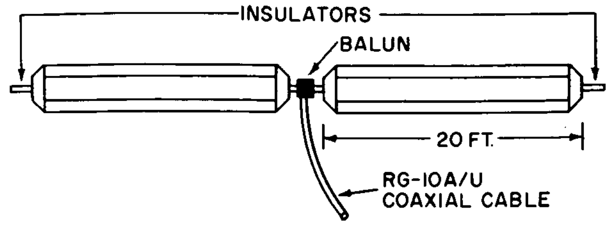


FIGURE 1-5. HORIZONTAL CAGE RECEIVING ANTENNA

1.2.4 Corner-Reflector Receiving Antenna

This antenna is similar to the horizontal-cage antenna described in paragraph 1.2.3 except that it is mounted on a boom over the starboard side of the ship. It is mounted to form the active element of a corner reflector antenna, with the vertical side of the ship and the surface of the water forming the reflecting surfaces. This antenna is used with a vertical receiving antenna in a polar-diversity receiving system.

1.3 FUNCTIONAL DESCRIPTION

There are effectively four transmitting antennas for each ship on two antenna structures, one at each end of the ship. This will allow a second transmitter to be tuned up while the first is in service, or would allow radiation from two transmitters at the same time.

One vertical receiving antenna and one horizontal receiving antenna are used together to form a dual polar-diversity receiving system.

1.4 EQUIPMENT SUPPLIED OTHER THAN ANTENNAS

Other components of the transmission system, such as shipboard filters and dipole antenna couplers are described in paragraph 1.4 of Part II.

SECTION 2. INSTALLATION

2.1 GENERAL INFORMATION

The antennas must be installed in accordance with Western Electric equipment specifications-284. Installation information is contained in Western Electric and Burns and Roe drawings.

SECTION 3. THEORY OF OPERATION

3.1 GENERAL INFORMATION

The transmitting antenna system consists of the transmitting antennas, networks, heliax-cable transmission lines and rf patch panel.

The polar-diversity receiving antenna system is made up of one vertical and one horizontal antenna, and the two transmission lines and filters.

SECTION 4· SYSTEM OPERATION

4.1 RECEIVING SYSTEM

The receiving antenna system consists of two vertical antennas and two horizontal-type antennas arranged for dual diversity reception. The vertical antennas are connected to RG-10A/U coaxial transmission lines. The horizontal antennas are center fed by RG-10A/U coaxial cable through a DAC-8, dipole antenna coupler (balun). The RG-10A/U cable is run to the filter cabinet where it connects to the receivers. The DAC-8 coupler is described in Part II, paragraph 1.4.1.5 of this manual. Selection of the best antennas are made at the receiver filter patch panel where the receiving antennas are terminated in tricouplers, facilitating more than one DDR-6 system being connected to the same antenna through different receiver filters.

4.2 TRANSMITTING SYSTEM

Four transmitting antennas are mounted on two structures on each ship, one structure at the bow and one structure at the stern. Each antenna is fed by two 1-5/8-inch heliax coaxial cables so that either the high frequency or low frequency section of the antenna can be selected depending on the operating frequency. The heliax cables terminate at the coaxial patch panel as described in Part II, paragraph 1.4.1.4.

SECTION 5. MAINTENANCE

5.1 CLIMBING AND SAFETY

Paragraph 5.1 of Part II also applies to this section on maintenance of ship antennas.

5.2 PREVENTIVE MAINTENANCE

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment, to eliminate major breakdowns and unwanted interruption in service and to keep the equipment operating at top efficiency.

5.2.1 Schedule

Routine intervals on the antenna system are listed in the Master Maintenance Schedule of MG-102, *Plant Operating and Maintenance Procedures.*

5.2.2 Maintenance Methods

Inspect the antennas for broken wires and connectors.

Inspect the antenna system for cleanliness of insulators and looseness of connections. Clean the insulators using a clean cloth and fresh water, then dry.

5.3 CORRECTIVE MAINTENANCE

Corrective maintenance for the shipboard antennas consists mainly of repairing broken wires. The manufacturer's installation instructions and Burns and Roe drawings can be used for maintenance work.

5.4 TOOLS AND MATERIAL LIST

Tools and material listed in paragraph 5.4 of Part III, Antennas-Land Stations, also apply to shipboard antennas.

5.5 TEST EQUIPMENT LIST

The test equipment listed in paragraph 5.6, Part II, is also used for shipboard antenna work.

5.6 PARTS LIST

The parts list given in paragraph 5.7 of Part II applies to both transmission lines and antennas.

5.7 DRAWING INDEX

The drawings listed in paragraph 5.8 of Part II also apply to shipboard antennas.